MACHINERY.

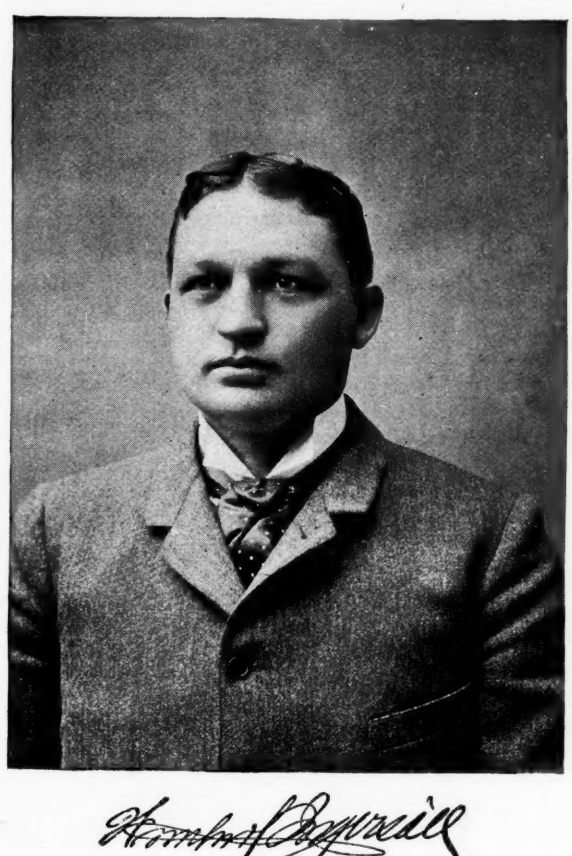
VOL. 2. October, 1895. NO. 2.

THE TEETH OF MILLS.*

WINTHROP INGERSOLL.

FOR a very long time, dating from the days of the oak frames of the first New England milling machines, the strength, efficiency and durability of the teeth of the solid steel mills which were then used almost exclusively, so greatly exceeded the stability and resisting powers of the milling machine frame, that very little attention was given to the mills themselves. The mills were nearly perfect from the very first. They were finer toothed, generally, than is now the practice, but otherwise they were fair examples of the tool maker's art, and answered every purpose perfectly, because the machines in which they were used had not the power of drive or the strength of frame needed to urge the mills to their limit of work.

Within the last ten years, however, all of this has been changed. The introduction of the milling machine into the machine shop led at once to heavy machines, powerfully driven, and the weight of the machine, power of the drive and diameter of the mill carrying arbor, and the arbor carrying milling machine spindle, and the formerly absurdly inadequate outboard mill arbor support, all have been and are being steadily increased, until now the general sentiment in the drawing room is that the milling machine cannot be made too heavy, nor can the mill spindle drive on the work table feed may be made too powerful.



Very early in the history of these changes in the art of milling machine construction, which closely followed the first attempts to introduce the milling machine as a regular part of the modern machine shop equipment for general use, attention was forcibly directed to the teeth of the mills.

The mere fact of increase in cut dimensions due to the increase of size of pieces milled, and consequent increase in the cutting tooth surface and mill diameter of the cutters needful to execute the work, carried the mill dimensions beyond the economical point of solid tool steel mill manufacture, and led to the bestowal of great attention on inserted tooth mills, made with small hard teeth inserted in comparatively large mill bodies of soft steel and cast iron.

These inserted mill teeth were held in all possible ways; the dovetail, screw and taper key being largely employed; the round taper pin driven between each two teeth with a thin screw cut dropped down through the middle of the pin seat to the circumference of the bottom of the inserted tooth seats in the blank, made a neat and favorite construction, largely used; it was also discovered that plain open rectangular seats, either parallel to the axis of the mill spindle, or cut obliquely thereto, so as to give a spiral or angular cut to the tooth, could be filled with plain rectangular teeth very slightly thicker than the width of the cuts, without special fastening devices, and still have the teeth sufficiently held for all classes of work. It also became common to make end mills by seating a circumferential row of teeth in a cast iron mill blank and holding them in place with set screws, and mills were also made, in some cases, with two sets of teeth, one of which could, by interior mechanism of the "universal chuck" order, be projected or withdrawn at will, so that either set could be put in action at pleasure, the object of this most elaborate and very extensive structure being to have the one mill body contain two sets of mill teeth, one to be used for roughing and the other for finishing. As the size of the work increased, the size, and consequently the cost, of the mill increased, and there immediately arose a great demand for cheaper mills, cheaper methods of construction, less costly tool making and more ready grinding of the mills.

These conditions have so far proved difficult to satisfy. There are methods in common use which greatly cheapen the mill construction, but the problem of cheap mill grinding has not yet been fully met by anything offered for public use. The common form of end mill having teeth of say $\frac{7}{16}$ inch or $\frac{1}{2}$ inch square tool steel slipped into circumferential seats in the mill body, and these, in turn, surrounded by a keeping ring having a set screw for each inserted tooth, makes a very cheap end mill, and one which may be, and is, cheaply ground by slacking up all the set screws, and removing all the cutters, perhaps twenty or thirty in number, grinding each separately on the emery wheel, and then replacing the entire assemblage in the mill body by dropping each tooth successively on a fixed surface and setting up its holding screw while the cutting point is so supported. This is quick, but does not answer at all for fine work because mill teeth so set never cut in exactly the same plane, and so make distinct "revolution mark," or mark measuring exactly the feed of the work table per revolution of the mill, in the work.

It was early discovered that in milling large surfaces better results could be had by breaking up the teeth of the mills. For a width of cut of say 24 inches, it was found better to use 6 mills 4 inches face to make up the 24 inches width of cut, than to use an unbroken tooth 24 inches long; in this case the short mills were so placed on the mill arbor as to be "staggered," or break cutting lines with each other.

Later it was found to greatly lessen the power required to drive the mills and move the work table for a given cut, if the teeth were notched in a quick spiral around the whole circumference.

The old tool maker's practice of cutting a shallow coarse pitch square thread on the finished surface of roughing reamers for taper centers in lathe and other tool spindles, was copied in this practice; the taper reamers were neither more nor less than side

* For illustrations see page 41.

cutting mills, and it should have been obvious that what aided the taper reamer in its work would also aid the mill. This fact was not readily grasped, and it was not until after Muir, of Manchester, England, had patented in both England and the United States his form of mills, which was precisely that of the taper fluted center reamer with a shallow square thread cut on top of the teeth, that we in America began to use this expedient very largely.

Our own experience as builders of milling machines for machine shop use led to the invention and patenting of the form of cutter tooth now known by our name. This invention was the result of necessity. Having great confidence in our machines, we had guaranteed a cut which proved upon trial to be beyond the driving power of the particular milling machine we had recommended and built to make the cut. It occurred to us that if the cut was very much broken up the mill would require less driving power, and at the same time it occurred to us that mill teeth made of short round plugs of tool steel driven into round holes in a soft mill body, would give a very cheap mill construction, and also one which was capable of being applied to mills of any length and almost any desired shape. The experiment was tried, and with the new plug tooth mill the machine proved amply powered for the cut which it could not pull at all with the old style of continuous cutting face tooth.

This style of inserted tooth mill is shown in place ready to work on a wide paper cutting machine table, in Fig. 1. Great numbers of them are in use, and it is perhaps, among the cheapest and easiest driving mills for a wide or narrow cut yet brought out. It is comparatively easy by its use to produce flat surfaces up to 36 inches wide, which do not vary more than one thousandth of an inch from a true plane, and hence it is largely used for surfacing work not required to be finished with greater accuracy.

For wide cuts, say from 20 to 36 inches in width, a very powerful drive and very heavy framing are required and supplied, as shown in the engraving, and even then with such substantial framing and good fitting the teeth of the mills invariably cut deeper on some one side than at any other point. This is true of all mills, no matter how constructed. Probably no mill was ever yet made or used which cut alike all round. This very heavy crossrail shown in Fig. 1 needs to be balanced to handle readily, and the latest machine of this class, in which the crossrail, which weighs nearly a ton and a half with a full width mill in place, is balanced by the requisite counterweights.

Massive as the framing of large milling machines has been, there is still a very great deficiency either in the milling machine or in the mills used with it up to the present time, although there is, in most cases, a very great gain over the production of the planer to be had in the use of the milling machine. Thus in case of the job shown in Figs. 3 and 4, of four troughs or ways for the "travelers" of platen printing process, in Fig. 3, the bottom of all four troughs of a set are shown as being surfaced at one cut, this should naturally give the four finished in half the time needed to plane the seats on the bottom with two tool saddles fitted on the planer crossrail. In reality the gain is very much greater, because the section of mill operating on each trough carries many teeth, a considerable number of which are in simultaneous action, and each tooth should be able to cut away as much stock as a single planer tool. In finishing out the inside of the trough, where the steel shoes on which the travellers run are seated, the milling machine shows to a very great advantage, as the four mills at one operation cut all four of the troughs, bottom and sides and tops, or sixteen surfaces in all, to size, and finish them perfectly without great skill on the part of the workman.

This is, of course, a very favorable example of the economy of milling. Machine shop superintendents should in all cases study well the character of the work which it is proposed to finish by milling instead of by planing; in practice almost all cases where there are several surfaces comprising the finished dimensions of the work, the change from planing to milling is economical. Such is also the case in many instances with wide flat or slabbing cuts. Again, the quantity of work to be produced in duplicate is always a very important factor in milling machine results. In general it may be safely asserted that any ordinary straight line surface can be finished as quickly by milling as by planing, by use of the planer frame style of milling machines, by a good hand who is really familiar with the operation of the machine, while a very great many of the surfaces to be finished in the ordinary run of machine work can be surfaced on the milling machine in a half or quarter of the time which a planer would use for the same work. As soon as it comes to a question of duplicating large numbers of pieces the milling machine is indispensable; its economy becomes so great that its use cannot be neglected. In many shops the type of machine here shown is in constant use on general work, taking equal rank with the planers as a tool for all kinds of jobs as they come in the current business of the establishment, and gives great satisfaction. When one machine of considerable surface dimensions, like the printing press, of which parts are here shown in process of finishing, is to be constantly built, a large reduction in cost of finishing the needful flat surfaces can be made use of this style of milling machine, with either horizontal or vertical spindles, or both, as may be most suitable, because the planer type of framing gives facilities for general use not found in any other form of milling machine.

To return from the foregoing digression, suggested by the great economy of milling in case of the troughs shown in the engraving, to the teeth of the cutters employed, the slabbing mill shown in Fig. 1 is 8 inches diameter and has eight rows of teeth, hence, the teeth are pitched a little over $3\frac{1}{8}$ inches, center to center; the trough mills are in gangs of 4 mills to each trough; the middle ones a pair with interlocked teeth, 8 inches diameter and 18 teeth, for cutting the bottom and inner sides of the trough, and the side mills, for cutting the tops of the troughs are 6 inches diameter with 14 teeth in each. At the periphery these trough mills had their teeth pitched by the foregoing figures respectively, $\frac{50}{18}$ inches=2.8 inches nearly, and $\frac{28}{14}$ inches=2 inches, while the slabbing cutter was as before stated, $3\frac{1}{8}$ inch pitch or distance from center to center of teeth circumferentially; but again, these teeth besides being much farther apart circumferentially, have not continuous teeth in the rows; on the contrary there is nearly a tooth width of space between the teeth, so that the "Ingersoll" mill has only about half as much width of cutter on the work at a time as the ordinary inserted tooth mill of the same length

Now the teeth of these mills are pitched $3\frac{1}{8}$ inches, and the teeth of the side mills in the trough gang are pitched only 2 inches and have a continuous cut, and hence would appear to have three times the tooth in action, when viewed circumferentially, that this cutter was using, suppose both to be used at the same surface speed per minute. But the teeth of the six inch side mills were spaced fully as far apart as the usual practice would demand. Hence the question arises, does the common practice put more teeth in mills than should be used to obtain the most economical results?

This is a question to which it seems very little attention has been given. We know that the old-time tool makers made their mills with very much finer pitched teeth than are now used, and consequently cut very much finer chips than a milling machine is now expected to produce. The practice seems to be constantly towards a coarser pitch for mill teeth. It would seem like a waste of power to cut the stock to be removed into finer chips than is necessary; in other words, given a certain section of iron to be removed in the form of chips, every continuous chip cut then represents a shearing of this entire section of metal; and it would seem to be an error to show this section of metal any more often than it is necessary to do so, and hence it would seem that this point of spacing mill teeth might profitably be the subject of closer attention than it has yet received.

Finally, it seems not unreasonable to suppose that, were the teeth of mills correctly spaced, so as to give each tooth its best effect, milling machines might show a much greater efficiency per horse power delivered into them through their now overworked driving belts, and their massive framing might be found to better resist the strains which, with the present close spacing of teeth, arise from the removal of comparatively small cross sections of chip with mills.

* * *

One of the most annoying and time wasting forms of carelessness is the order for a machine or any part of it, which does not give half the necessary details and leaves the recipient to guess at the remainder or wait until further instructions are received. Be sure you give exact sizes, the production or shop number and any other details possible, especially the work in hand, if it is in any way out of the usual order, as it may require special parts or fitting. This is particularly true of any appliance that is made in more than one grade for different kinds of service. A little attention to details in ordering will save time, money and ill feeling.

ON THE TRANSMISSION OF POWER BY ROPES.

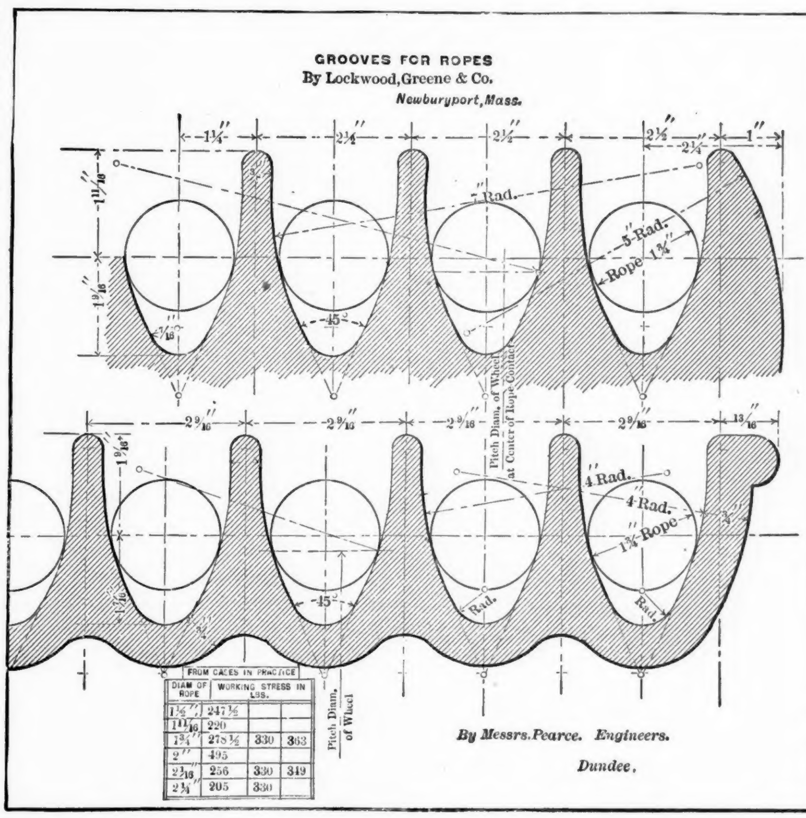
JOHN H. COOPER.

The transmission of power by ropes in grooved prime-moving pulleys was first made an accomplished fact in the year 1863 by Mr. James Combe, of Belfast, Ireland. Later on, Mr. James Durie, in a paper read at the meeting of the Institution of Mechanical Engineers, Manchester, England, in the year 1876, presented the accumulated facts and data then existing; following these, Prof. Unwin, in his "Elements of Machine Design," formulates in a brief, readable shape, "the facts of things," from a considerable range of experience with ropes which had become worthy of record as engineering precedents, and since this issue much and varied matter appertaining to this method of carrying power and motion to places of need in the factory, will be found manywhere in the journals of technical literature.

The following summary does not claim to embrace all that can and should be known of this subject, but it presents in condensed form a profusion of leading facts and data which have been purchased by experience with and discussion of this comparatively new method of motive continuous transmission.

The use of cords for pulling, be it known, is as old as the earliest created animal, indeed all muscular action in animals and in man, is dependent upon tendons or cords for moving attached parts. But these are limited to short and repeated pulls, while the funicular system here treated is for the maintenance of continued motion with great power from the motor to the machinery to be driven.

First of all, the statement must be made that neither ropes, belts or gearing will serve best for all cases of power transmission. Which one shall be used must be decided by the intelligent engineer from a consideration of all the circumstances controlling each particular case.



FROM CASES IN PRACTICE

DIAM OF ROPE	WORKING STRESS IN LBS.		
1½″	247½		
1$\frac{11}{16}$	220		
1¾″	278½	330	363
2″	495		
2$\frac{1}{16}$″	256	330	349
2¼″	205	330	

As a general rule, ropes should be run under very much the same conditions as leather and other belts. That is to say, the working tension of each rope should not nearly reach, and should never exceed, its elastic limit, the pulleys should be comparatively large and each connected pair set apart as nearly horizontally as may be, to secure the greatest advantage of "sag" upon both pulleys, and that the speed should be high in order that the traction may be light. The direction of motion should be such that the lower strips of the ropes will drive; following this, the upper strips would hang in deep catenary curves between the pulleys, which would increase the arcs of contact upon them and contribute as well to the elasticity of the system. If one shaft must be above the other, care should be taken to avoid vertical lines of running for either strip, but if one strip must be vertical let it be the driving one, and that in the case of the lower wheel being much larger in diameter than the other. As with belts, the greater the velocity of the rope the greater the efficiency of the same, and the speed may safely be increased up to 5,000 feet per minute. The driving and driven shafts may be located (as they must be in most cases, according to circumstances), we may say, for main drivers, a distance apart horizontally of from 20 to 60 feet, whatever be the vertical distances.

The wheels are usually made of cast iron, but wood is preferred by some; in either case they may be constructed in whole, in halves, or in segments, with separate rim, arms and hubs, as may best suit the making, fitting and shipping of them. The grooves should be accurately turned to the same shape, fitting the ropes to be used in them and to exactly the same diameter in the same wheel, in order that the pitch or driving diameter of each groove shall be equal, it being essential also that the effective diameter of each rope in each connected pair of wheels shall be the same, and that the wheels shall be well and evenly balanced in order that when used for high-speed running they may move without lateral vibration. Roebling's rule for wire rope driving will apply to those of organic fibre, naming the least ratio of wheel and rope diameter, as 35 to 1.

Rope wheels intended only for bearing up the sag of running ropes, or guiding them where necessary, should have a diameter not less than that prescribed for the least driving wheels, and the grooves should be smooth with semi-circular bottoms and larger than the ropes, to permit the freest passage of them when on the run through the grooves.

The ropes used are mostly of hemp, cotton or manilla, of carefully selected stock, having long fibres. They should be well and regularly twisted and uniformly "laid," and yet be soft and evenly elastic. A matter of great importance is a well made splice; no part of it should be of greater or less diameter than that of the rope itself. Whether "short" or "long" splices, both are much talked of, but a long splice and a long fibre in the stock of the rope are so near akin that the same argument would apply to both with equal force.

The driving power is due to the grip or pinch of the ropes in the angular groove of the wheels; the ropes can therefore be run loosely, that is, with light, primitive tension, which secures that important advantage of unnecessary transverse straining of the shafts and useless pressure upon the shaft bearings,

White untarred ropes will break under a strain of 7,000 to 12,000 pounds per square inch of section. The actual section conforming to the above estimate may be taken as that within $\frac{9}{10}$ of the circumscribing circle of the rope.

In general the life of a rope is from three to five years, the latter durability having been many times exceeded in practice; some are known to make a record of ten and a half years of continuous running. When a rope shows signs of failing it can be removed during a noon stoppage and a new one can be replaced in about the same time; but driving ropes should be removed before the breaking act to avoid an unpleasant tangle, and may be a tragic breakdown.

In the allotment of driving capacity for every installation, provision should be made in the wheels for one or more ropes than the exact number necessary to do the work intended, so that should one fail in the course of running, the remaining ropes would be fully competent to continue the driving of the plant.

There is a considerable difference of opinion among rope users as to the proper angle of the V grooves in the wheels: angles of 30°, 35°, 43°, 45° and 60° being in use and named for the inclination of the sides; the 45° angle having been in use during thirty-three years, since its first introduction by Mr. James Combe.

Some writers recommend straight-line faces and others concave, in which latter it may be said a rope would certainly have more surface in contact, while the word of caution must be spoken for any and every angle and shape of groove,—*the ropes must never touch the bottom of their grooves.*

Notice must be taken of the fact which is graphically represented on the drawing, that the pitch diameter of the wheels from which relative speeds are to be calculated, must not be measured

from the centers of the ropes, but from the centers of the rope contacts in the grooves, or from some point between the two depending upon the amount of stretch of the rope at its center and upon the slip of the touching part.

As to the comparative cost of rope transmission an English authority says: "It is difficult to give exact figures for this comparison, but the cost of rope-gearing is considerably less than cog-gearing for equal transmissions, and it may be fairly set down as one-half or two thirds of cost of leather belts on flat-faced pulleys."

The American authority named on the drawing cites a case of their own planning and erection in Lawrence, Mass., where they have about 2,000 H. P. in ropes (this was about eight years ago). The round figures given are $10,800 for the belting gearing and $6,700 for the rope gearing.

The following table will show the transmitting power of ropes at velocities ranging from 3,000 to 5,000 feet per minute, as derived from cases in practice, from which the H. P. can easily be figured when the exact velocity in feet per minute of the ropes is known.

Diameter of Ropes. Inches.	Working Stress on One Rope. Pounds.
$1\frac{1}{2}$	247
$1\frac{11}{16}$	220
$1\frac{3}{4}$	278
$1\frac{3}{4}$	330
$1\frac{3}{4}$	363
$2\frac{1}{16}$	256
$2\frac{1}{16}$	330
$2\frac{1}{16}$	349
$2\frac{1}{4}$	205
$2\frac{1}{4}$	330

According to M. Leloutre and others the friction of a new hemp rope on a flat-face pulley =0.075, and in a semi-circular groove it is = 0.088. Morin's experiments of dry leather belts on flat-face pulleys give 0.282. Prof. Unwin uses this figure and multiplies it by the co secant of half the angle of the V groove, which for an angle of 45° would give a co-efficient of friction =0.7 for an ungreased rope used in such a groove, which should be halved with the employment of grease.

These deductions show very clearly that for best rope driving we must avoid flat working faces and such forms of grooves as would permit the ropes to touch bottom.

The loss by *creep* of the ropes is important, but it is difficult to estimate owing to so many variables entering the problem, such as the wheel grooves may not be alike, neither in form, smoothness or pitch diameter, and the ropes may vary in diameter, texture and strength; the greater these variations the greater will be the creep. When twenty to thirty ropes are used the loss by creep has been estimated at ten per cent.

The relative creep of the ropes themselves may be ascertained by painting a band of showy color across all the ropes and then noting their several positions at regular subsequent periods of time. Their creep upon the pulleys must be calculated from the revolutions of the prime moves of the transmission.

Quoting from the results of experiments by Morin, the rigidity of new white cords and tarred cords is dependent upon their natural stiffness, which we will call A. The effect of the tension on the cord by which its hardness is increased, we will call B; then if we call the diameter of the wheel plus the diameter of the rope D, we may establish a formula thus, and say the total resistance due to rigidity will be equal to

$$\frac{A+B}{D}$$

which can be worked out easily when the elements of each case are known.

The leading resistance therefore varies in the inverse ratio of the diameter of the pulleys. Of course it is trebled on a third diameter of pulley and halved on a double diameter, showing at sight the advantage of the larger diameters of pulleys for all drives. Moreover, the bending resistance increases with the tension, which is included in the element B, and the traction of the rope in its groove is lessened somewhat by the rigidity. All the components and results of stiffness are therefore reduced by increasing the diameters of the pulleys

There are cases not satisfactorily possible with an 8 inch flat belt, but which may be easily managed by a ½-inch diameter manilla rope; such as with shafts near to and vertically over each other, also where the distances asunder of shafts is too great for a single belt drive, also where the shafts are not parallel and where the transmission must be carried around corners and obstructions, to all of which simply attached and inexpensive guiding pulleys for the ropes may be applied.

A correspondent says he has never had good luck with iron wheels; he thinks wood is best. The iron wheel will get too smooth for good driving, and he would make the V groove straight from the top down. He further adds: "By all means do not let the ropes touch anything, or touch each other, and they must not run on the bottoms of the grooves." He does not approve of two or more ropes, each in its own separate groove, according to the English system of rope driving; he would run one continuous rope, which would imply that he favors the American system as invented, advocated and made by the Dodge Manufacturing Co., of Mishawaka, Ind. He says the grand difficulty with rope transmission has been on account of the *splicing*. He favors the long splice—sailor made—which is done without loss of fibre, working strength or enlargement of rope, and which cannot be seen when so made.

Mr. T. Spencer Miller, in Trans. A. S. M. E., vol. XII., 1891, says: "If we are to use lubricated ropes we certainly should use a sharper angle in the groove." Reuleaux, Ramsbottom and Yale & Towne use a 30° angle for the groove, and I hope to see the best American practice use 30° or 35° as the standard angle. The effort to pull out a greasy manila rope from a 30° groove is not worth consideration. I am strongly in favor of the *continuous rope* system and of using *smaller ropes* therein. The most perfect transmission (20 H. P.) I ever saw, employed $\frac{5}{16}$-inch manilla ropes on 30-inch diameter wheels and using a tension carriage.

Mr. Miller has patented a system of employing different angles of grooves in the driver and driven pulleys which promises well. "In order to cure the unequal pull on the strands of the rope, the grooves of the large driver were made 60° and of the driven 45°." "This change of groove has proven satisfactory." "In dynamo drives I would advise using 45° for the driving sheave and as sharp as 30° for the driven."

The writer emphasizes the importance of perfecting this system by the use of smaller and better ropes running at higher speeds in properly proportioned wheels and rope grooves; slso that the ropes should be in one continuous strand or in pairs.

My friend, Mr. Samuel Webber, prefers a 60° angle for giving the best holding *surface* for a circular rope, delivering it also more freely. The best practical groove I have seen is an English one; it is 53°. He prefers hemp to manila, quoting old sailor experience with running ropes, who say, use Riga hemp. He refers to the fibres of cotton as being the strongest known of equal area and considers ropes of cotton far preferable, for rope driving, to ropes of manilla.

He startles us with the unwelcome news, just when we are in the heat of advocating ropes, by quoting the total f ilure of a big rope drive, "after *one day's* run; a second set of ropes lasted *ten days*, and then they went back to leather." Now, dear Mr. Webber, don't we all know that "There's nothing like leather," and haven't you just referred to hemp and to cotton as having admirable qualities? Of course *this* rope drive was a bad installation. We do know that the several systems of rope drive have commercial importance, and the names associated with a multitude of successful examples in all of them are sufficient guarantee of commendable merit.

Finally, the ropes should be put upon the pulleys with little initial tension, and never strained to straightness of both strips. When the lower strips are under load, the upper strips gather the slack and drop into curves, which increase their arcs of contact in the grooves.

Ample driving friction should be obtained chiefly by the weight of the ropes, in which case they are not pinched or worn away unnecessarily by the grip of the grooves upon them.

The commercial economy of power transmission by ropes may be summed up as embracing the maintained existence of at least six conditions, namely: small diameter, great tensional strength, high speed and durability of the splice of the rope, large diameter of the wheels for reducing the bending action of the ropes and the best traction surface in the grooves of the wheels. These requirements will apply to ropes of wire as well as to ropes of organic fibre.

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MESSRS. JOSEF SCHVARCZ & Co., machinery and hardware dealers, Buda-Pesth, Hungary, are desirous of representing American manufacturers in that country.

HOW STRIKES MAY BE AVOIDED.

The following extracts from the report of Mr. David N. Burke, United States Consul at Malaga, Spain, will be interesting to those who are desirous of harmonious relations between employer and employed. While it may not be a solution adapted to every case, and while there is probably room for criticism of some of the points mentioned, there is much to commend a careful perusal of the article to every thoughtful person.

"Facts relative to labor in every country show that too often the laborer, while 'worthy of his hire,' does not receive the wages he should receive for the services rendered. Facts show that he is often ill-treated, oppressed, and with little attention given to him by his employer and less concern as to his welfare or that of his family. The walking delegate, socialistic agitator, or so-called labor leader, takes advantage of this unfortunate method of treating employees to prevail upon and urge well-meaning and sensible laborers to 'go out on strikes,' which generally ends in the defeat of labor, together with untold suffering to those dependent upon the strikers.

"In Malaga to-day, exists a very striking and practical working of what the law of kindness, as employed by an employer to employees, has effected. Here are located two cotton mills. Both have been in operation some forty or fifty years. One is called La Industria Malaguena, the other La Aurora. They stand side by side. The former employs about 3,800 hands, and the latter some 2,000. The operatives in each—men, women and children—belong to the same class of people. They are, of course, the humbler class—the poorer class of the community—possessing, the men and women, as well as the boys and girls, the ordinary amount of native common sense and intelligence that persons of their class possess in any country. Whether these operatives have a fair amount of 'book learning' or not I do not know, but it is to be supposed that children of poor parents do not have opportunities for acquiring school knowledge, even if they were so disposed, especially when, as is frequent here, many of these children enter the factory when under 10 years of age. Many a girl and boy, however, may be seen going to and returning from work in one or the other of these mills with as much native intelligence stamped upon their faces, with eyes as bright and keen, step as quick and haughty, and with as much grace and ease of action and manners as if they were the daughters and sons of merchant princes or college professors.

"In the La Industria Malaguena, as already stated, more than once since its doors were first opened, discontent, dissatisfaction, and unrest have been apparent, terminating in strikes and distress, want and suffering. Whether the operatives have had just cause for pursuing the strike policy or not, I do not know. That such a course was, however, followed at different times by the different operatives in this mill since its inauguration shows, quite as conclusively as can be shown, that, at times, the course of the company towards its employees was such that it did not prevent, even if it did not engender, the strikes.

"But how has it been with the other cotton mill—La Aurora—the owner of which is an uncle of the chief owners of La Industria Malaguena, and is now a man upwards of 75 years of age? How has it fared with the operatives of La Aurora since its inauguration some forty years ago? The same class of men, women, boys and girls have been employed in this mill as in the other. But during all these years, in which so many changes have taken place in the complexion of La Aurora, men and women, boys and girls dying, or leaving the mill for one cause or another and others taking their places, how is it that there has been no strike, no grumbling, no unrest, no complaints, no whisper of discontent? Have higher wages been paid in this mill than in the other? No. Have the hours of labor been less? No. Has the work been less laborious or fatiguing than in the other? No. Is there a different class of persons employed in this mill than in the other? No. It is simply this: Senor Don Carlos Larios, the owner of the mill and employer of the operatives, applies the law of kindness to his employees. As every one says, he treats them well, he treats them kindly; he recognizes that his employees are flesh and blood, as he is. He realizes that when hurt, they feel the pain just as he would; when without food, they are hungry, just as he would be. He has, in fact, substituted the law of kindness for the practice of greed. If an employee is sick, he sends a doctor to look after him and pays for the necessary medicines. In case the employee's illness continues, he pays, on recovery, the wages the person would have received had he or she been at work during the time. In case of the death of the employee, the wages go to the family of the deceased, and, besides, if the circumstances of the family are such as to require it, he defrays the expenses of burial. When his operatives marry, Senor Don Carlos, as he is called, helps to 'set them up' in housekeeping by presenting to the married couple several household articles which are indispensable for those entering such a state. Extrordinary diligence and care on the part of the employee in his or her work, or greater activity displayed by an operative, are duly recompensed in some way at some time by the proprietor of the mill; and every operative, being aware of this, seeks to do his very best. The superintendents of the mill cannot be overbearing or oppressive toward employees in this mill, unless they are anxious to lose their job. 'Like master, like servants.' The same spirit of kindness which the owner practices toward his employees must be practiced by the subordinate superintendents in their different departments. So this spirit is contagious; all are moved and influenced by it.

"The operatives have no labor organization. They need none, unless it were one partaking of a benevolent character. When Labor Day (May 1) is being celebrated by the labor organization, the operatives of La Aurora are at the mill in the morning as usual. It may be they go on with the work all day as customary; or it may be Mr. Larios appears and says to the paymaster: Give each person double pay for the day and close the mill that the operatives may enjoy themselves; or it may be a bouquet of rare flowers or some other surprise is in store for the employees. Through this law of kindness, the business of the mill is conducted. Discord, dissatisfaction, discontent, unrest and strikes are not on the programme of the operatives of this mill. They have no use for labor agitators. If an operator has any grounds of complaint, he goes at once to Senor Larios and states his case. But even complaints are rare, as the overseers are very careful to treat the employees well, partly because, if found on investigation they are at fault, they will be retained no longer in their positions, but chiefly on account of the spirit of kindness existing between operatives and superintendents, which has come, through the influence and example of the proprietor, to be regarded as one of the requisites for the success of both the employer and the employed.

"So it comes to pass, through the law of kindness inaugurated by Senor Larios when the mill was first opened, forty years ago, that no breath of discontent has ever been breathed against him. He has made it an essential among overseers and operatives that no other spirit than that of kindness should find a resting place within the four walls of his mill. The 2,000 employees love Don Carlos, as they call him, as they would a father; and if anyone should be known to speak ill of him in the presence of any employee, the employee would resent it as if the ill-spoken word were uttered about the employee himself.

"In an interview with Mr. Larios, he informed me that his rule of life has been to treat everyone with kindness and to supplement kindness, wherever required and it could be done, with charity. Said he:

"'If I ill-treat or abuse, what can I expect, what should I expect, but treatment of a similar kind administered to me on lines corresponding to the moral and intellectual status of the person I abuse? It is largely due to the greed of employers and their not knowing their employees, not knowing their circumstances, their condition of life, trusting too much to exacting and overbearing overseers and superintendents in their relation to employees, that the differences, the disturbances, the ill-feeling between labor and capital arise, resulting in strikes and lock-outs and often carnage aad slaughter of human lives, and always in suffering and misery. As superintendents and overseers, an employer should have humane men, kind men, feeling, sympathetic men. If they are not such, and are so constituted that they cannot or will not become such, then employers should not have them. I will not have as overseer or superintendent such men in my employ. Then, again, an employer should know his employees, as far as it is possible for him to know them—who they are, how they live, what their circumstances are, etc. I am president of a society which my employees have formed for the good of all, and, though a busy man, I go among my employees. I know them; they know me. We understand one another, and if employers are inclined to be just and fair, there need be no conflict between capital and labor.

"'I do not know what other cause to attribute the absence of discontent, dissatisfaction and strikes in La Aurora during the last forty years but to the spirit of kindness I have practiced toward my employees, the dispostion I have shown to treat them well, to treat them fairly, to treat them justly, and to extend charity to those needing it, as well as to give them the wages due them. In fine, I have endeavored to follow the precept of the Divine Founder in doing unto others what I would they should do unto me.'

"These are the words of a man who has solved the most important question—the paramount question—affecting Christian

governments and Christian society to-day, and solved in such a manner as to endear him to every operative within his mill. Had the proprietor of La Aurora given his law of kindness a trial for one, two, or three years with the same 2,000 persons to deal with during the time, employers carrying out the practice of greed for themselves and manifest unfairness toward their employees might say the law-of-kindness method in such a case is simply an experiment and would not prove successful if put in practice for any length of time; but here are forty years in which the law of kindess has been tested, and not with the same operatives, but with hundreds of changes in the mill during the time. It could not be attended with greater success.

"Wherever, then, the law of kindness is adopted by employers toward employees, as Senor Don Carlos Larios has practiced it for forty years, there will be no question between labor and capital. The logical and the natural result will be what it has been in this case."

* * *

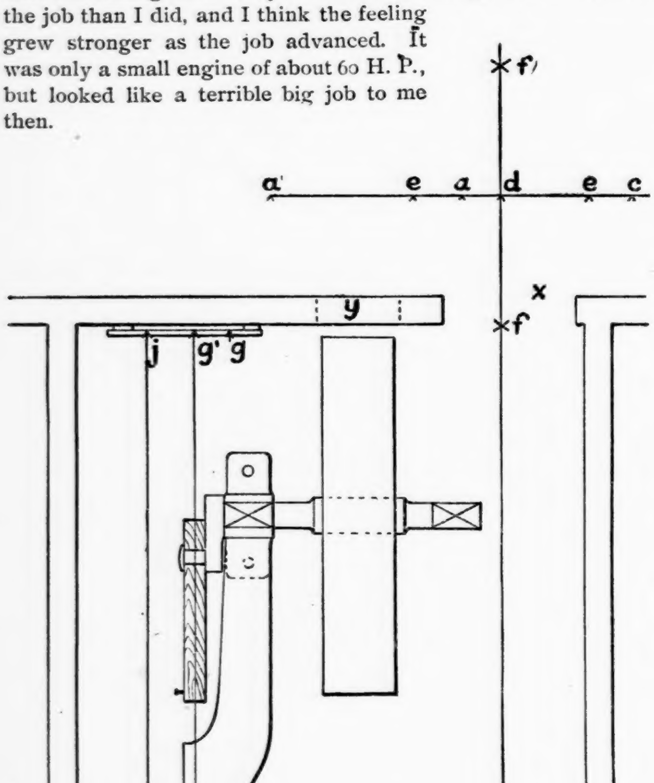
ERECTING AND STARTING ENGINES.

"SPIKE."

I suppose everyone has his own ideas about his particular business, and when some one tries to give points on the subject they are very liable to conflict. And by this article I don't intend to establish a rule for erecting or starting an engine, but to give a few pointers and kinks that I have tried and found good, hoping they will be useful to others.

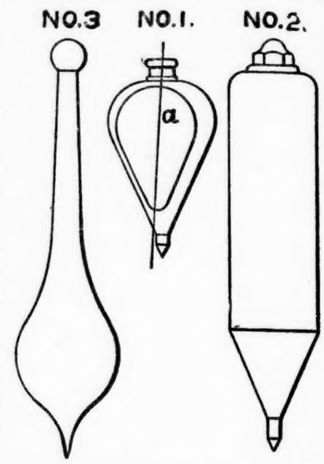
When I set up my first engine I wished a great many times that I had some one to give me pointers on the job.

I believe everyone, before starting out on a job that he is not acquainted with, should be sent out as a helper with an experienced man until he is capable of handling the job alone. If I had had that opportunity I should have felt more independent on my first attempt at setting up an engine. But I started in with the feeling that everyone that came along knew more about the job than I did, and I think the feeling grew stronger as the job advanced. It was only a small engine of about 60 H. P., but looked like a terrible big job to me then.



If anyone knew how I felt when that engine was ready to start I don't think they would envy me the sensation.

No one from the shop came near me after I started the job to give me any instructions or advice (although the job was within a mile of the shop) until I was ready to turn steam on; then I got word by telephone not to start until the superintendent arrived. Then I wished I had let the telephone alone and started the engine at my own risk, and sent for the superintendent afterwards, but there was no help for it then. I felt as though I would like to start that engine in the middle of the night when no one was around, and I am not sure but I would have liked to be away myself for the first few revolutions. But the superintendent came and the first question he put to me was, "Do you think that belt will hold?" I put on a bold front and told him that I did. Then he wanted to know how I got the crank-shaft in line with the jack-shaft, and to save my neck I could not tell him, but made a big bluff at it, and he laughed and said he guessed it was all right, but if it wasn't we would soon find it out. Great consolation for me. Well, after looking around awhile and asking a few questions that I think he knew I couldn't answer, he opened the throttle valve and the engine started and ran in the right direction, and the belt ran all right, neither to one side or the other. In fact the job turned out all right, requiring but very little tinkering after starting up.



I have thought of that job many times since, and wondered if the firm were not running quite a risk in sending me out alone, without any experience in setting up, although I had worked in the shop for them for some time and had done some outside repair jobs.

But I have set up a good many engines since then, and feel as though I could give a few pointers that will be beneficial to those that are young in the business.

To begin with, after arriving on the scene and having made yourself known to the proper authorities, just take an hour or two, or more if necessary, with the engineer or whoever you are to look to for information, help, tools or blocking, and the various other things that you will need sooner or later, and go over the whole ground and get acquainted with it and the ones you will have to do with. Find out where the parts of the engine are and whether they are all there or not, and which part you must get in first, and not have it interfere with the others as they come in. Determine on the number of helpers you will require, also about what you will need for large tools, such as chain and rope falls, chain and rope slings, and screw or hydraulic jacks and the like (unless the shop furnish them), and have them on hand early, so that when you want to have them to use there will be no delay in getting them.

Right here let me say a word in regard to the help. When you determine on the number of men you want, have it distinctly understood that they are your men until the job is complete, as it is very disagreeable to have a man taken off occasionally and another put in his place, as it generally takes from one to several days to get them so they can all pull together.

Don't call for any more men than you can keep busy, as idle men standing around are a nuisance and do more toward prolonging a job than to work short handed at times. I have never had a job where I could work over four men to advantage, except when I had some one I could put in charge of another gang. Of course there are times when it is necessary to have more men for a short time, but there are generally enough men around to call on at any time.

Before getting in any parts of the engine, get your targets up and put them up securely; then if some one runs against them they will not get displaced. And I find it very convenient to have two sets of them, one level with the center of the engine, the other say six feet above it, or high enough to be out of reach of accident or anyone that wants a piece of board. Then when you get your points for the center line of the engine onto the

lower targets, plumb up and make corresponding marks on the upper ones also. Then if the lower ones get disturbed you won't have much trouble to make them right again.

Don't trouble yourself to set targets or points for the center of the crank-shaft, as I will tell you of a better way to square this later on. We will suppose that the jack-shaft is in, and you have got to set the engine to line with that. Proceed as follows:

Clear a space on the floor under the shaft as large as necessary and plumb down from the shaft in two places as far apart as possible, and plumb from the side, first calipering the shaft to make sure it's the same diameter at both places where you plumb from.

Here let us talk about plumb-bobs a little. The first plumb-bob that I used was the regulation hardware store arrangement familiar to all (see sketch No. 1), and it got me into lots of trouble, and for this reason: It was brass, cast hollow and filled with lead, and the brass was about $\frac{5}{16}$ inch thick on one side and $\frac{1}{32}$ inch on the other. The lead being heavier than the brass brought the center of gravity to one side, or on line *a* No. 1, and the shape kept it well up; consequently the error was magnified considerably at the point. That plumb-bob met with an accident, or I probably should have never known how it was constructed or why its point would scribe a circle if it got to whirling. Then I made one like No. 2, of a piece of steel $1\frac{1}{8}$ inch diameter by 4 inches long, which I considered all right, and used it for a long time with lots of good chances to give it away, which I finally did, and then made No. 3, which I thought couldn't be improved upon. But I am going to make one more, and it will be like No. 3, only it will be about 9 inches long, while No. 3 is only 5 inches. It will have a long, slim neck $\frac{1}{4}$ inch diameter, and will be made of tool steel instead of soft steel. For lines use a braided silk, and in the long run you will find it much cheaper and will certainly give enough better satisfaction to offset the extra cost. But let us get back to our job. After getting marks on the floor *a a'*, as per sketch representing the line of jack-shaft, we want to establish a line at right angle to it, and that line must run clear through the engine room and be transferred to the targets. Now the only place to get through the brick wall with the line is at the door-way *x*, or at the belt-holes *y*, one below the floor and the other way above. Let us take it through the door-way, as I think that plan less liable to error than the other. First get some wire nails and drive one at *a'* (I say wire nails because they won't cut the line), and fasten the line there and stretch it through the point *a* to *c* and make it fast there. Then make a point *d* opposite the door-way; from this point measure off any convenient distance, say 6 feet in both directions on line *a' c*, making the points *e e*. Don't use a two-foot rule to measure with or a tape-line either, but take a light strip of wood, hard wood if you can get it, then you can make the measurements right and know that they are right. You will find that the success of the whole job depends more on the accuracy of this lining than anything else, and I find it is time well spent to tack down a piece of tin or zinc, to carry these points, unless there is a good hard-wood floor, as it makes one feel so much more confident in his work after the last point is established.

We will assume that it is twelve feet between the points *e e*, each the same distance from *d*; now take a strip of wood say 10 feet long and drive a nail (with points well sharpened) through each end, so the points will project both on the same side, to be used as trammel points. Place one point at *e* and with the other scratch the arcs at *f f*, then stretch a line through the points designated by the intersection of the lines *f f* and extend it to the extreme end of the engine room, and you have a line at a right angle to the jack-shaft and parallel with the center line of the engine. Now measure accurately at each end of the engine room from this line to a point under the targets and plumb up and establish a point on the upper edge of the targets, say at *g g*. You will now find a mark on the wall or old target representing the center of the balance wheel, wheel-pit, belt-holes, etc., if it has not been obliterated; if it has, establish a new one. Then, knowing the distance from the center of the wheel to the center of the engine, measure back that distance from the center of the wheel-pit onto the target and establish a new point *g'*, then get the distance from *g* to *g'* and establish a corresponding point on the other target, these two points *g' g'* represent the center line of the engine. I generally find that all these main points have been established once for the masons to work to in building the foundation, but I never use them, as they are not reliable as a general thing.

One case I well remember in a new power station. I started to erect two pairs of engines, and they told me to go ahead and work to the marks on the wall, that they said were established by a surveyor's instrument, and if they were not all right they would stand the blunt of it. Well, I got the first pair all set up and started on the next, when I found the center lines were not parallel by $\frac{7}{8}$ inch in sixty feet, and the first one was not right by $\frac{5}{16}$ inch, making the second one out $1\frac{3}{16}$. I don't remember just the remarks I made about the job, but I formed some new resolutions on the spot, the principal one being to depend on my own points to set an engine by.

These two points *g' g'* and two others on the same targets that we will establish later are all that are necessary to line the engine by.

We will now get in the different parts of the engine. In this case, the engine being situated as it is, it will be necessary to get in the half of the wheel that goes in the pit first. The wheel is supposed to be in halves, and has got to come in through the opening marked *x'*, which is not large enough to let it in on its side. If it is brought on a truck from the car or is taken directly from the car, set it on its edge when unloaded, as the truck or car will act as a large pile of blocking, and will stand firmer than any blocking I ever saw. In taking the wheel off the car, first get two good stiff timbers as long, or a little longer, than the diameter of the wheel, for shoes to move it on after it is on its edge, and place them alongside the car, and if the wheel has got to go in the direction of the track put rolls under them on a good solid runway, but if it has to go in a direction at right angle to the track, raise them up so the bottom will be a little above the top of the track, and under the center place a cross-piece stiff enough to carry the whole load when supported in the middle by a large washer like a jack-screw cap, placed on a good solid blocking. Then on top of the shoes build a cob-house blocking to the top of the car, and slide the wheel out onto it, leaving about a foot of the ends of the rim on the car. Then make a chain fast in the lower bolt-hole in the rim at each end and to a stake iron on the other side of the car, to keep it from slipping when lowered down on to the shoes. Lower it down by means of the jack-screws, and after it strikes the shoes complete the job with the screws and blocking between the wheel and car. After getting it in an upright position on the shoes, chock it in a manner that will allow the half wheel to be lifted by jacking under one end of the shoes, the other end resting on blocking. Then jack up one end and remove enough blocking, to let the washer sustain the whole load. Then place blocking to form a balancing track, keeping it as high as possible, and allow the shoes to swing over it and not bear hard upon it; if you find it bears hard at one end throw in a few pieces of blocking or a man or two to balance it. Then move the car along the track out of the way, and with a man at each end with a shoulder against the rim you will be surprised to see how easy a ten or fifteen ton weight can be turned one-quarter, one-half, or a whole turn if you like.

Care must be taken, of course, and not let the blocking get displaced so the wheel can tip to too great an angle, as there is danger of its going clear over. After getting used to turning heavy parts in this manner, I think you will agree with me that it is the easiest, simplest and most expeditious manner to do it.

After getting this half of the wheel in the pit let the other half come next, in the same manner, only the other side up. Run it into the engine room and leave it standing out of the way, only convenient to be run onto the other half when the crank-shaft is in place.

Next get holding-down bolts in their holes and screw on the bottom nuts the proper distance to allow the bolts to come through the lugs on the frame and cylinder and flush with the top of the upper nut, as it is easier to hold the nut in the pocket under the foundation and screw the bolt into it, than it is to crawl into the pocket and screw the nut on from below. Then get the engine onto the foundation and bolt the cylinder, frame and crank-bearing together. Then put a target in the crank end of the guides, also in the open end of the cylinder, and stretch a line between them to determine if the guides are in perfect alignment.

This work has been done in the shop once and is all right now probably, if there is no dirt or foreign substance in the joint, but if the frame and cylinder were shipped separate don't erect the engine without knowing that they go back together all right. Now get the bolts up and get the top nuts on three or four

threads, enough to hold them from dropping. Then stretch the line through the cylinder between the points g' g' on the targets, and draw it tight, and measure up roughly and see if the bolts will allow the engine to come into place. If they won't, find out which ones bind and relieve them so that they will be perfectly free when the engine is in place. Now bring the engine up level and in line. To level it use a spirit level in the bottom guide and in the bottom of the cylinder, and plumb the edges of the guides, also the spot that the crank runs against, and if it is a Corliss engine level the tops of the inlet valve chambers. Get these spots right and never mind the rest. Use iron shims or wedges to level up with. When level and in line, raise the bolts until the nuts come against the foundation plates below and block them there. Fill the holes around the bolts with fine dry sand. Then when you pour the grout or soft metal it will not run in and bind the bolts. Some people prefer to have the bolts grouted in, but I don't, as it is sure to give some one lots of trouble some time, and I think it is but very little help toward holding the engine in place.

* * *

COMBUSTION AND STEAM MAKING.

William O. Webber.

As stated before, 18 lbs. of air are required for the combustion of one lb. of coal, and this air should be supplied in uniform quantity. Unfortunately this cannot always be done, owing to the fact that firemen are not careful enough to always keep a uniform amount of fire on the grates. With six inches of fire on the grates we will assume that the proper amount of air will be supplied to make good combustion—now if we increase the depth of this fire to ten inches, we do not get air enough through it to support good combustion, and the carbonic acid gas which rises up from the green coal on top of the fire becomes converted into carbonic oxide and at the same time steals carbon from the coal in excess of what it needs or can carry, after this is done it is no longer combustible when present in excessive quantities and it goes up the chimney as black smoke—after depositing a coating on all the surfaces of the flues, etc., with which it comes in contact, and rendering them more impervious to the transmission of heat than before. Soot, or the deposit of carbonic oxide from coal, is nearly as good an insulator against heat as glass or rubber is to electricity. If an engineer wanted to get a good connection to an electric wire from his dynamo, we hardly think he would wind the binding post with rubber tape—and yet that is exactly what he does with his boiler when he carries too heavy a fire and winds the surface of his flues with a dirty black coating that thoroughly insulates them from the fire and prevents the heat from getting through into the water inside the boiler.

As a matter of fact, about ninety-nine out of every one hundred boilers have too heavy a fire on the grates. This statement will

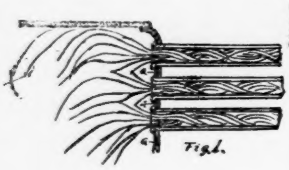


Fig. 1.

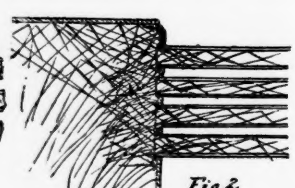


Fig. 2

be contradicted by ninety-nine out of every one hundred engineers who read this article; and it is just as true, nevertheless, as that about the same number of failures in amateur photography come from over-exposing the plates.

It has always been a mystery to the writer ever since he first wielded a coal scoop on a locomotive of the Boston & Maine railroad, why a man would insist on shovelling six or eight tons of coal for a day's work when four or five tons would do the work. The only reason he could think of was that the men wanted to do the extra work for amusement. Now, the writer always imagined that he was "constitutionally tired" and never wanted to do any more "work between meals" than he had to. So he set his brain to work instead of his hands and found that he could get along with less work required of the latter the more he used the former.

The greatest trouble he has noticed in the fire-room is that the disposition seems to be to fill the furnaces up so that they will not have to be attended to again for as long a period as possible, leaving the fireman a longer period in which to smoke or tell "Pat" another new story. This is the only reason why a mechanical stoker will eventually drive all the firemen out of the boiler room. A good intelligent fireman *can* produce just as good and economical results as a mechanical stoker—and better—***but he won't.*** The only advantage that a mechanical stoker has is that it puts a little coal on the fire at a time and does it often. We never used to put on more than one scoop full of coal at a time without shutting the fire box door, and a man who put in more than two scoops full at a firing was considered a poor fireman. We recently made some analysis of flue gases at a place where the fire-door was left standing wide open for a period long enough to allow the fireman to put in ten or twelve large scoops full of coal, and this was the result:

New Fire.	Carbonic Acid Gas...........	11 per cent.
	Oxygen (Air)..................	5.6
	Carbonic Oxide (unburnt).....	3.2
		19.8

After this fire had been burning twenty minutes the Carbonic Acid was 4.4 per cent., the Oxygen 15.4 per cent., and the Carbonic Oxide so small as to be unrecognizable, showing in the first case much too heavy firing, and in the latter case too much air passing through the fire on the grates.

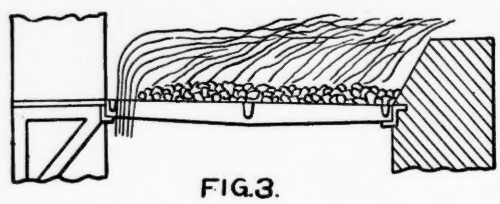


FIG. 3.

Another feature in the transmission of heat which has been seldom alluded to is what we should term heat impact, for want of a better term—what is meant by this is, that if the flames and heat from a fire are impelled directly against a surface they will heat it hotter and convey more heat through it to a liquid or gas beyond it than if the same heat and flame is only allowed to pass alongside and "rub up against" this same surface. Why this is so the writer candidly confesses "he does not know." That it is a fact he thoroughly believes, and has seen many examples of its proof and talked with many men who believed the same thing.

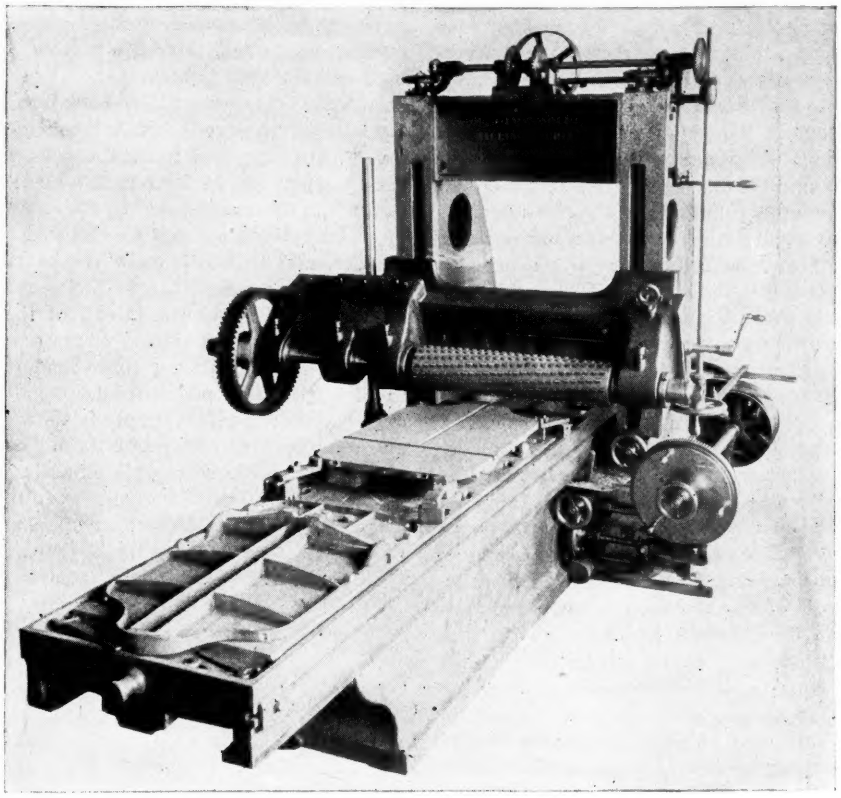
Perhaps one illustration which would be comprehended by the average engineer would be this: In the fireplace we all know that blowing a fire makes it much hotter than "sucking" it would; in other words, that an artificial draft produced by a blower is much hotter than the same amount of draft produced by an exhaust fan.

A locomotive tube sheet stands perfectly well under the exhaust draft produced by the exhausting steam in the smoke box, but all experiments to run with a fan blowing into the fire have burnt out the tube sheets and had the flues leaking in a short time. We imagine the cause is this—with the exhaust draft the flames and heat are drawn into the tubes as in Fig. 1, forming a cone shape as they enter the tubes and begin to assume the spiral that all gases and liquids do when in motion to avoid friction; and this cone shape makes the flame and heat avoid the sections of flue sheet between the tubes at points marked "A," and also the corners of the tubes where they are beaded over. You can verify this experiment by noticing the flow of water through a round augur hole in the bottom of a box, or in the wash bowl in a bathroom. While on the other hand, when the fire is forced by a blast —it strikes at random and bounds back and forth, and would enter the flues and strike against the tube sheet as in Fig. 2, filling the whole box full of fire and heat which would crowd its way against all parts trying to find an opening to get out of, and impinging against every available point and then rebounding off again and striking some other point.

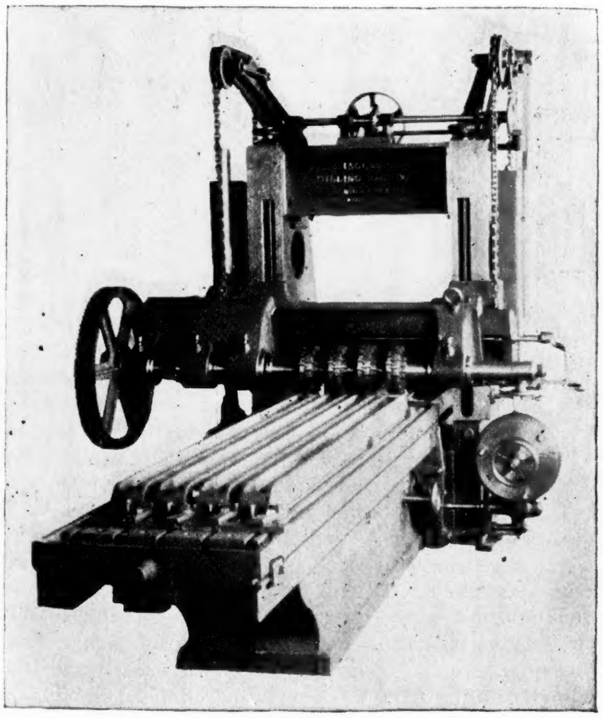
Perhaps a better illustration yet is the fact that may be noticed in an ordinary wood burning stove having two elbows in the pipe, one near the stove and the other near the ceiling of the room where the pipe enters the chimney. A hot fire of shavings built in the stove will make the pipe red hot at both elbows, while between them the pipe will remain black.

And this feature of impact of heat is why we think that the shell of a boiler does more steam making than the flues and why such good results are obtained from some of the internally fired boilers like the Scotch marine boiler and the more familiar Galloway type; although the combustion cannot be nearly so perfect owing to the lowering of the temperature of the fire by the close proximity of water on the water side of the fire-box sheets when the chemical decomposition of the coal, called burning, first takes

place. After this has taken place and the proper amount of air has been mixed with the hydro-carbons to make perfect combustion, the cooling influence of the adjacent water does not seem to make so much difference. In other words, keep out of the furnace of your boiler all water circulating pipes, water legs, etc., with fire light enough to allow of all the air necessary passing up through the grates, or else admit air through the damper in the fire door—which is generally not large enough and can usually be successfully supplemented by pushing back the fire directly in front of the door so as to admit some air through the grates at this point, as shown in Fig. 3. This air will unite with the flames and be all burnt up before it gets up to the flues and will make a much hotter fire. Close your ash pit doors somewhat after your fire has burned off its first effects and you will be surprised how much fire you can save, or, in other words, how many tons of coal a day you can avoid shovelling, and also that by doing this you are making much less ashes, which you must rake out and shovel up and wheel off at night. For if five tons of coal, well burned, are enough, you only ought to have say six hundred pounds of ashes, or three wheelbarrows; while if you use seven tons of coal for the same work, you will surely have eighteen hundred pounds of ashes and have to shovel out nine barrow loads. This is no fancy statement.



THE TEETH OF MILLS.—See pp. 33 and 34.

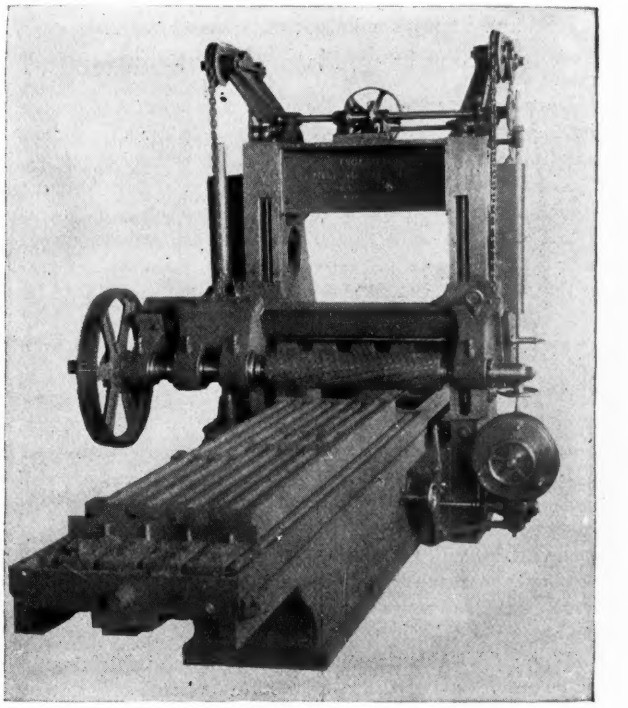


THE TEETH OF MILLS.—See pp. 33 and 34.

MACHINE BUILDERS' RECORDS.

HENRY HESS.

This term is defined as a system for keeping track of the details entering into the construction of machines; it therefore, includes the preservation and indexing of all drawings used, as well as the recording of the machine details themselves. Many plans for this purpose are in use, but of all that have come to the writer's knowledge none that are at all simple are sufficiently comprehensive, and none that have the latter quality combine with it the use of a minimum number of drawings or of simple records that do not entail complete re-writing with every change of design. In the plan to be presented it has been sought to avoid the loss of time and the possibility of error attendant upon copying drawings of details when used for different machines, by always using the same drawing, though the detail it represents should enter into the construction of half a dozen, otherwise different machines. To this end the individual detail piece has been selected as the foundation of the entire system, and as some symbol is required to distinguish it from others the simplest possible one, a number, has been selected. A number, when applied to a detail is never again used, so that it absolutely distinguishes its piece from all others, without the necessity of qualifying symbols of any kind. It has been sought to minimize the labor of recording changes by providing lists that are common to a whole series of similar machines, arranged in such manner that only the changes



THE TEETH OF MILLS.—See pp. 33 and 34.

and additions need be recorded as they are made, the unchanged record being utilized without rewriting. It has been sought to so arrange the lists that they will constitute a simple and completly comprehensive chronological history of the evolution

of a machine from its first to its latest form. It has been sought to so arrange drawings that any individual sheet may be quickly found or returned to its proper place, and yet to have all drawings pertaining to a given machine assembled in a bunch for handy reference without having to first collect them from various places and to redistribute them after consultation. It has been sought to so arrange things as to render the smooth working of the system independent of any one's memory and to make it easy for a person of very ordinary intelligence to carry it out successfully. Probably as good a way as any to present a plan realizing these requirements is to transcribe the governing rules with an occasional explanatory note.

1. Every detail as made is given a number. Such number is taken from a consecutive number list book. (As it is used but once, this number will absolutely differentiate its detail from all others). When a pattern is needed it receives this number. Following the number a short and as fully descriptive a name as possible of the piece is entered into the list book, followed in turn by symbols of the various machines into whose construction this piece enters; as from time to time new applications are found they are properly entered. (This record of the various machines a piece is used for, becomes of value when a question arises of the relative advisability of changing a pattern or making a new one).

2. When a detail is so changed that it cannot be used in place of the original, it receives as a new number, the first that the consecutive list book shows to be free.

3. Material is indicated by a symbol prefixed to the piece number: O is used for wrought iron or steel, and OO for brass or bronze. (Further than this nothing is attempted as the large range of available materials will render their symbolizing more complicated than the use of the ordinary technical terms).

4. Each machine as a whole is given a symbol consisting of a capital letter or combination of capital letters; these are taken from a machine symbol list in alphabetical order; the name of the machine is entered in this list. (Symbols indicating a machine by the initial letters of its name are to be avoided as, aside from the fact that various persons naturally employ various names for the less common machines, a limit is soon reached when this plan results in repitition and confusion).

5. Each machine symbol is to be followed by a small letter that is changed for the next in alphabetical order each time that the design is changed. (A design is thus known as "a" or "x" and not as "standard" or "regular," terms which are absurd since in the march of improvement the "standard" of yesterday is discarded for the "regular" of to-day and the "improved standard" of to-morrow).

6. Machines having similar general characteristics but varying in size are marked by having the actual distinguishing dimensions prefixed to their symbol.

7. Drawings are made in standard size sheets of which the largest is 39½"x26". Smaller sheets are obtained by continuous binary division. Size is indicated by a fraction as ½, ¼, ⅛, etc.

8. Each sheet is given the number of the detail drawn on it, together with the symbols of the various machines it is used for (this last only for convenience in conversational reference). It follows that only one piece is drawn on a sheet; the smallest sheet that will contain this piece to an adequate scale is to be employed. (The use of the same number for both piece and sheet does away with the finding index required where these numbers differ).

9. Construction or assembly drawings are given numbers that are taken from the same consecutive number lists used for the details; a descriptive name of the drawing is entered in that list.

10. Each detail is marked on the assembly drawing with its symbol. (The assembly drawing thus becomes the most convenient key possible for the identification of any piece, as very few persons will describe even the more common details of machines by similar or mutually understandable names; but they can always find their numbers by pointing out the pieces in question on the assembly drawing).

11. When a detail is but slightly changed, and this change can easily be made on the drawing, a thin paper blue-print of this latter is first taken and filed away in the place of the original drawing; the latter is then changed and filed in the order of its new number. This plan of saving drawing work is to be made use of only when there is a fair certainty that the old sheet will not again be required for blue-printing. Any doubts are to be resolved in favor of making a new drawing.

12. Drawings are filed in consecutive numerical order in flat trays capable of accommodating conveniently twenty-five sheets. Larger sheets are folded, smaller sheets are not cut apart.

13. A complete set of thin paper blue-prints is to be taken of each machine; this is to be permanently bound and filed away in a separate nest of trays in the alphabetical order of the machine symbol. These sets are to be used for reference, the original drawings for blue-printing only. (Where saving in blue-print is deemed important, reference sets of only the more frequently used machines are to be prepared).

14. A "machine record" in book form is kept of each machine. Each left-hand page is devoted to columns for entering the piece numbers in numerical order, the piece names and the number of each piece required for one machine; each right-hand page is devoted to columns headed by the design symbols, *a*, *b*, *c*, etc.

15. In making out the first record the left-hand page is first filled in, and then column *a* of the right-hand page the piece numbers are duplicated.

16. In making out the record of the second and succeeding designs, the new or changed pieces are entered on the left-hand page, while in the proper right-hand page columns are entered the numbers of all pieces used. Opposite the pieces not used a dash is entered; this is simply to show that the number has been purposely omitted. Opposite those pieces directly superseded by new ones the superseding piece number is entered in red ink.

This form of record gives, with the least possible labor in original compilation, a complete history showing at a glance when a piece has been first used, when it has been discarded and for what piece, and when, if ever, it has again come into use.

* * *

GEAR-OLOGY.

F. W. Clough.

HOW TO FORM CONJUGATE TEETH.

A pitch of wheels is a list between two extremes of the same sized teeth, as usually is employed, of twelve teeth to a rack; less than twelve teeth is not practical, nor necessary to use, as a rule.

To use either extreme of a pitch to generate the teeth of the other wheels, gives a form to teeth which will interchange with each other.

There are a variety of systems in tooth forming, and the teeth of one form system will not interchange with other systems in shaping teeth. A convenient method is to use a proper form of rack tooth to generate teeth.

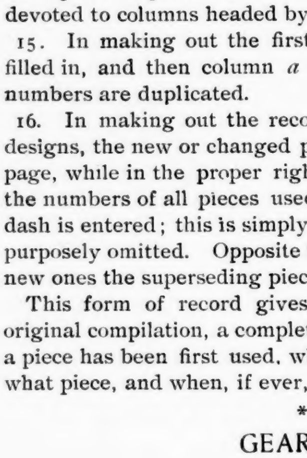


Fig. 1.

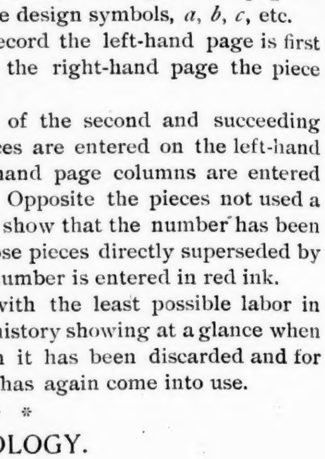


Fig. 2.

Fig. 1 illustrates this: A is a cutter of the form of a cycloid rack tooth; this cutter is mounted on arbor A^1, which is also mounted on bearings fastened to slide A^2; B is the section of a wheel pivoted at E; B^1 is a lathe tool fastened to wheel section B.

Now it follows that if A^2 and B be carried forward and back from *o* to *o* at a uniform rate on lines C C, while cutter A is rotating, that lathe tool B^1 will be milled out the exact contour required to be cut out by cutter in gear-cutting machine. When tool B^1 is thus shaped as dotted lines indicate, then it simply remains to relieve the under side of shape, harden and use in lathe to give proper shape to cutter required to cut twenty teeth, as in example; the radius from E to C is for that number of teeth. If other number of teeth are desired, then the radius should be for that number of teeth, and shape thus milled in tool and used as before to correctly obtain form of gear cutter.

Fig. 2 illustrates another method of obtaining the same result. F is a worm cutter (no teeth shown in cut, simply form of tooth

cutter) of the ordinary 29 degree involute rack, H is a section of wheel and teeth, such as this worm by rotating will cut. When the cutting is done, the worm being of proper lead, wheel H is driven by a feed movement which in speed at C C are uniform; on H is fastened tool G, which, when milled out by F to proper shape, is also properly relieved and hardened, fastened to lathe tool and used to give proper shape to gear cutter. In Figs. 1 and 2 the top side of tools should be on line with center of cutters A and F.

The method shown in Fig. 2 can be used in gear-cutting machine without making cutters by using tool G to make other cutters, provided the gear-cutting machine be fitted for driving gear blanks at the proper speed, while spiral cutter F is fed across the face of wheel and the blank rotates; this method produces a whole pitch of wheels by the use of one cutting mill like F, and in thus cutting, the teeth of all the wheels are milled up just the correct shape.

* * *

THE STRENGTH OF GEAR TEETH.

George Guntz.

Or to make it more clear, what shall be the pitch of the teeth on a gear wheel, to transmit a given horse power. When we want this information, if we don't carry it in our heads, we look into the reference books, and see that

$$\sqrt{\frac{H.\ P.}{V.\ P.}}=B\ 60$$

or

$$P=\sqrt{\frac{H.\ P.}{T\ B\ R\ .0006}}$$

and half a dozen more that are about as intelligible to the uninitiated, but when the occasion demands we want to know, and we want the information with as few figures or assumed quantities as possible. Years ago, when I was looking for an easy way, I came to the conclusion that D. K. Clark's formula, based on 1800 as the co-efficient for the ultimate strength of cast iron, was about as easy a one as I could find, and I have used it ever since with satisfactory results. By dividing the 1800 by the factor of safety, for instance, if we want to use a factor of safety of $4\frac{1}{2}$," then $1800 \div 4\frac{1}{2} = 400$, and the formula be written

$$P=\sqrt{\frac{S}{400}}$$

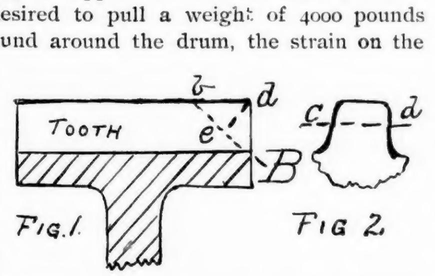
It will be observed that the formula does not take into consideration the H. P. the breadth of the teeth, the number of teeth, the revolutions or any constant, only the one which is made for the occasion, by dividing 1800 by the factor of safety, using the quotient as the divisor in the formula, it simply says divide the strain by 400, and the square root of the quotient is the pitch.

When a machine is designed, the strain. *i. e.*, the pull, the push, the power given out, is, we might say, always determined before the pitch of the teeth in the gear is thought of, and the same can be said of the velocity. Now this force is the strain, which is considered in the formula for the pitch of the teeth in the gear. As an example, suppose we have a drum 5 feet in diameter, and it is desired to pull a weight of 4000 pounds attached to a rope wound around the drum, the strain on the rope would be 4000 pounds at the periphery of the drum, $2\frac{1}{2}$ feet from the center of the shaft, the strain is that which the tooth will have to be made strong enough to bear, and it is evident that if this strain is $2\frac{1}{2}$ feet from the center of the shaft on the drum, the point at which it acts on the gear must also be $2\frac{1}{2}$ feet from the center of the shaft to balance that on the drum, *any other distance would make it more or less*, and the wheel would be 5 feet in diameter. Such being the case we apply the formula by saying $4000 \div 400 = 10$, and the square root of 10 is 3.164, which is the pitch. This, you will see, not only gives the pitch but the diameter as well. But you say you want a wheel smaller or larger; in that case you can fix the diameter to suit yourself, but you would have to find the proportionate strain which would come on the tooth at that diameter, as, for instance, you want a wheel 4 feet in diameter. The strain on the tooth would be greater at 2 feet from the center of the shaft than at $2\frac{1}{2}$ feet; so by proportion you would find the strain at that diameter as 4 feet is to 5 feet, so is 4000 to 5000 the strain wanted, and $5000 \div 400 = 12.5$, and the square root of $12.5 = 3.55$ inches pitch. Or if you should want a 7 foot wheel, you would say as 7 is to 5 so is 4000 to 2859, and $2859 \div 400 = 7.14$, and the square root of $7.14 = 2.67$ inches pitch. Now let us take for another instance a crank press designed to give a pressure of 2000 pounds, with a crank 4 inches long, then $2000 \div 400 = 5$, and the square root of 5 inches 2.41 inches pitch for a wheel the same diameter as the crank circle; this would give a wheel with a little over ten teeth, and you never would think of a wheel of that diameter as the wheel you would put on a crank press to give out 2000 pounds pressure; but you would like to have a wheel say about 24 inches diameter, then as 24 is to 8, so is 2000 to 666.6, and $666.6 \div 400 = 1.666$, and the square root of 1.666 is 1.29. But a circle just 24 inches diameter is not exactly the size to make the teeth come out even on the circumference, and right here is a good place at which to bring in the speed for consideration. Suppose you want to run the crank at 20 revolutions and driving shaft at 100, this would give a speed of 5 of the driver to 1 of the crank, and your wheel would have to be proportioned to these conditions. Now as the circumference of a 24 inch circle cannot be evenly divided by 1.29, you would have to take the nearest circumference which could be so divided; also the quotient must be a number that can be evenly divided by 5, the proportion that the speed of the pinion is to the wheel, the circumference of a wheel is divided by 1.29 would give nearly 59 teeth this you cannot divide by 5, but if you add another tooth, making it 60, and $60 \div 5 = 12$, the num- of teeth in the pinion, and the diameter of a circle which has 60 teeth of 1.29 pitch on its circumferece is 24.637, or a little over $24\frac{5}{8}$ inches.

Then, again, you might want some particular pitch, say an inch for easy figuring. It's a poor rule that don't work both ways, and as this one will it must be good; one way it says

$$P=\sqrt{\frac{S}{400}}$$

and the other way it says $P^2 \times 400 = S$, that is, the square of the pitch $\times$ 400 = the strain which the tooth has to bear; the strain and the crank equals 2000 pounds. Taking 1 inch pitch, the square of 1 is 1 and $1 \times 400 = 400$, and as 400 is to 2000, so is the diameter of the crank circle to the diameter of the gear, which in this case would bo 5 to 1 as the crank circle is 8 inches the gear would be 40 inches. So far there has been nothing said about the face of the wheel, so again I will refer to Mr. Clark for something easy. The tooth of a gear wheel is a beam fixed at one end and loaded at the other and as the available strength of a wheel tooth is its weakest point, the strength should be calculated for the contingency that the whole force is applied to one corner d (see Fig. 1), and under uniform conditions the actual line of fracture would be on the line *b*, B, and it is evident from this reasoning that the distance *d e* would be the length of the tooth or beam then it will be seen that if the tooth is deep enough (that is from *c* to *d*, Fig. 2) to resist the strain, the face wheel need not be broader than the length of the tooth from *b* to *d*, which is about 0.75 of the pitch, therefore in order to allow for contingencies not considered we can safely say that $2\frac{1}{2}$ times the pitch is broad enough.



* * *

As the old question is being revived of grinding tools and other articles on the "front" (or side running *down*) or the "back" (or side running *up*) of the grindstone or emery-wheel, we shall probably hear the advantages of both sides, which will be beneficial to the younger mechanics in the shops. And after all is said and done, the majority will keep on grinding as they did before, some one way, some the other, and too often without proper consideration of the conditions at hand. There are places where each method may be advantageously used.

A CHEAP MILLING MACHINE.—2.

CHUCKS AND CUTTERS.

Having the milling machine, the next question is to make a line of chucks and cutters for the work in hand, which shall also be cheap and still be capable of doing good work.

The style of chuck shown on the machine in the September issue will answer nicely for a large variety of work which can be held in this way, and includes numerous sizes of coupling and stuffing-box nuts which are large enongh to allow sufficient thickness of metal between the nut and spindle for a chuck. Smaller sizes can be made, as shown in Fig. 5, where the nut is screwed down on the chuck C, until it bears on the collar A and just raises

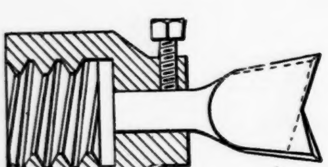


FIG. 1.

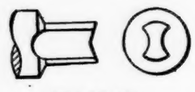


FIG 2.

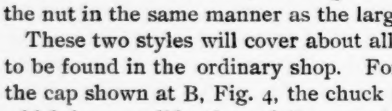
FIG. 3.

the chuck from the table; then tightening the nut beneath clamps the nut in the same manner as the larger chucks.

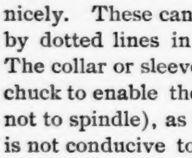
These two styles will cover about all the range of nuts that are to be found in the ordinary shop. For work with a shoulder, as the cap shown at B, Fig. 4, the chuck shown at A (same figure), which is a modification of the one in Fig. 5, will do the work nicely. These can best be adapted to the female spindle shown by dotted lines in the sectional view in the September issue. The collar or sleeve should be a little longer than the body of the chuck to enable the work to be solidly locked to the *table* (and not to spindle), as with a cutter running 1,500 turns a minute, it is not conducive to quiet nerves to have the work come loose. There is usually a sound that would do credit to a saw-mill, and then the nut goes sailing across the room like a shot, and it is better to avoid entertainment of this character. Other forms of chucks will suggest themselves as the work in hand differs from the kinds shown.

CUTTERS.

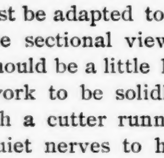
When it comes to cutters we are treading on dangerous ground, for there are as many opinions regarding this as there are makers of milling machines. The writer has never seen a regular multi-toothed mill which could touch the single point "fly cutter" for milling the sides of brass nuts, and the cost of the two cannot be spoken of in the same breath. The fly cutter I refer to is held in a chuck made by turning up a piece of machinery steel about $2\frac{1}{2}$ inches in diameter by 3 inches long, and threading one end for the lathe or milling machine spindle, then milling a $\frac{3}{16}$ inch or $\frac{1}{4}$ inch slot across the other end and putting a set screw at right angles to the slot to hold the cutter in place. Then taking a bar of tool steel $\frac{3}{16}$ or $\frac{1}{4}$ inch thick, as preferred (the writer prefers $\frac{3}{16}$ inch for ordinary work), it is laid off as shown in C, Fig. 4, and cut with a chisel (either cold or hot), *cutting only on the side shown.* A little study will reveal the reason for this: the chisel cut makes the clearance on the right side to run forward in the chuck on the speed lathe was one to use for milling and reduces the guiding to a minimum. Having cut off as many as needed (say a dozen, for the cost is comparatively nothing, as it only takes about two inches of $\frac{3}{16}$ by 2 inch bar for each cutter), they can be hardened immediately, treating the point in the same manner that a cold chisel is tempered, only hardening about one-half an inch of the point. This lessens the liability of breakage, and when soft they can be hardened if not worn enough to throw away, as it doesn't pay to spend much time on old cutters, new ones are too cheap. These cutters are particularly pretty, but they do work that no regular cutter can hold a candle to, if they are run fast enough, fed evenly and there is no lost motion in the machine. The work of the regular milling cutter on brass work is decidedly "frosted" due to the markings of the teeth, while this cutter, when in good condition, gives a clear, even surface without a scratch or mark of any kind. The usual fly cutter used in brass milling machines is rarely satisfactory for nice work, as it has four cutting edges, which are hardly ever ground evenly, and are usually high in the center and low at each end of the tooth. They will mill off brass in a hurry, and after a monkey wrench is used on the nut a few times, you can't tell the difference; but for nice work they are not to be considered unless they are ground with the points even and slightly in advance of the rest of the blade.



C



B



A

A speed of about 1,000 feet per minute gives good results with the fly cutter mentioned, making about 1,200 revolutions per minute for a point one and a half inches from the center. These can be varied in diameter, but it is not advisable to use them on work that will not admit of a cutter two inches in diameter, and for "shoulder work" of any side, such as the caps shown at B, Fig. 4, it has been found better to use cutters as shown at Fig. 1, having the edges ground parallel with the axis of revolution or at the angle required; the cutter shown is intended for end milling, such as small nuts and similar work. For this class of work this kind of cutter can be used with either one or two points, as indicated by dotted line, showing the lower point broken away. It was an occurence of this kind that taught the writer the value of the single point cutter in this case; one point broke off in the middle of a hurry job, and as a forlorn hope it was tried in its broken condition, when to our surprise it worked just as well as before. The chuck for these is also shown in this figure, and is as simple as the other, the objections to the crowding action of the set screw can be obviated by flattening one side of the shank, grinding the sides of the cutter with a cutter grinder while being revolved, and always clamping in that position.

The other cutters shown in this group are handy for what might be termed routing work, such as slotting the ends of tubes or castings, or any work that needs to be done in this manner. Either form will work well when given a proper clearance, although preference is given to Fig. 2 for work of this kind. This is not a back down from advocating a single-point cutter, for the work is entirely different. Where only a single surface is to be milled by a sweep or end mill, as in milling the sides of nuts the single point will do better work than more cutting points, *unless great care is used in setting and grinding cutters;* in fact care far greater than is often bestowed. For a "cheap milling machine" the multi-toothed cutters are not to be tolerated, as the difference in first cost and cost of grinding and keeping in order is something enormous.

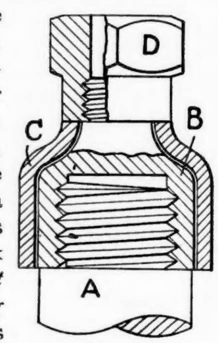


FIG. 5.

There is considerable experience to be gained in using these fly cutters; the grinding is quite a knack, but easily learned. The tendency is to get the point too blunt and rounding, but the best results are obtained by only slightly rounding from an acute angle, just enough to give a smooth finish to the work. A very little oil-stoning is beneficial, but too much is apt to be done, which results in dulling the cutters as much as milling several nuts would do.

The spindle of the speed lathe used for this work should be stiff and capable of being nicely adjusted endwise, as any lost motion in this direction is sure to show in the work by marks or scratches, which do not add in the least to its beauty. A little care in looking after details and attention that no lost motion be allowed that will affect accuracy, will insure good results at a comparatively small outlay.

It must be thoroughly understood that this is not a competitor of the regular milling machine for brass work, but rather an *appliance* which will do good work and can be afforded by almost any shop. But in spite of the difference in cost the quality of work will compare very favorably, and the quantity that a bright, energetic boy can turn out in a day will astonish those who think that only a "double-header" can do any work.

* * *

WITH few exceptions the leading machine tool builders have strengthened their machines, enlarged bearings and in a general way make them heavier and more efficient, as modern tools should and must be.

Any additional information concerning this will be cheerfully given at any time.—THE AUTHOR.

NOTES FROM NOTOWN.—4.

ICHADOD PODUNK.

There is a new foreman in the next shop, and although he has only been there about three months, he has made an impression that is pleasant to see. He didn't issue any new order sheet, or set of rules, and as the old ones were pretty well soiled, he threw them in the scrap basket, and for once there are no rules with their threatening penalties hanging over the shop of the Sterner Manufacturing Co., who were noted as being the most relentless employers in Notown.

Frank Jones, which was the new foreman's name, was a thorough mechanic and engineer; could file, chip, and run any tool in the place with the best of them, and had built, set up and run engines of about all sizes; consequently he knew how work should be done, how long it should take, and a good deal of human nature into the bargain. Some of the men began to smoke at their work, others to knock off a little early and wash up, others to carry papers and reading matter to the wash rooms, just to try the new foreman. But no set of rules resulted, and instead the offenders were quietly requested to forego these luxuries in working hours. A few persisted and were informed that another offense meant discharge, and one or two summary dismissals were all that was required. All this time he was quietly studying his men, finding their good and bad points, work best suited to them, and last but not least, in gradually getting the great mass of dirt, broken castings and other junk cleaned up from around the lathes. There was no splurge or bluster whatever about him in any way, and you would hardly know that anything was being done till you saw it accomplished. And better than merely cleaning up, he *kept it cleaned.* No one missed the rules after a few weeks, and in their stead he hung an attractive picture. Men came in on time just the same, or had a gentle reminder from the new foreman, and when it was found that he meant business there was no need of rules on the walls, for each man knew he was expected to do what was right, and if he failed, knew he must give a good reason or walk the plank; in fact, each man carried the rules in his head, and didn't have to walk half the shop length to find them.

Pretty soon new tools began to appear—jigs for drilling and tapping; fixtures for holding work in the chucks, new boring bars, etc., until all thought that ruin would surely follow the extravagant outlay. Then the orders for small parts began to given for a thousand in a lot; larger parts were made in lots of one hundred, while the heavier portions were made in lots of ten, twenty or fifty as required. Of course, Frank Jones had trouble with the office, that's to be expected when one tries to inject life into a mummy, but his quiet ways and positive assertions were gospel to the president of the company, who wasn't a mechanic, but who knew enough about raising hens to know that it costs a good deal less per head to raise a hundred than one; and Jones kept pegging away at the new system.

There was a little breeze when the manager came in one day and wanted him to finish up two machines right away, and Jones replied: "You agreed to let me get out a lot of twenty machines when I told you what I could make them for in lots of that size; now you want me to break into the lot for two machines. I can do it, of course, but you will be responsible for the cost." "But haven't you got the parts nearly made, and can't you get two together in two or three days if you put the men at it?" "To be sure I can, but that's just what I don't want to do. If I stop work on the parts now under way, it means lost time in 'tearing down' the machines, and more lost time in getting ready for the other pieces; then when two are made there is more lost time in getting to work on the lot again. If you say 'Make two,' I'll do it, and you'll have the extra expense charged to your office, and not to the shop, for I'll not shoulder the extra cost, when, by waiting two weeks you can have the two machines finished with the lot, and the rest within a few days, at considerably less per piece than as though you break up the lot as you want to do."

This is a point that too many managers (and foremen too, for that matter) seem to forget, that interruptions cost money, and that a man can do more work by keeping at one thing than by switching from one job to another, not counting the time lost in changing, and here is the secret of economy in large lots.

Well, Jones had his way, and in two weeks, as he had said, the machines began to be completed, and as it was the first time an order had ever been out when promised the president was more than pleased, and would have backed Jones if he had wanted to build a flying machine. There were several sizes of machines, and Jones had planned things well and sensibly, for he had gone over all drawings—made all parts practicable alike in all machines, had made up parts for all sizes, and when the machines began to be set up they turned them out like sausage out of a mill, and for once in the history of the concern its warerooms were stocked and the cost had been reduced to a reasonable figure.

Jones is also a man who knows how to wait, when waiting does more good than anything else, and it sometimes does. There was a countershaft of a planer that had given trouble: would heat up in two or three hours' run, throw oil and raise Cain generally. Jones told manager he must have a new counter; manager thought that ought to do awhile longer, but Jones said the planer didn't start on another job till it was fixed. Manager neglected to order counter, and when a job came along that must be planed, Jones sent it over to our shop and we planed it. When the bill went in the manager was wild. "Why, Mr. Jones, this company wouldn't have put themselves under obligations to the Notown Manufacturing Co. for anything, and the idea of throwing away money by having work done outside." "Obligations? Do you consider a man who buys your machines under obligations to you? I should call it the reverse by the way you hustle around when a possible customer comes into the shop; and as for throwing away money, I sent that job outside *to save money.* How? Well, that planer countershaft won't run over two hours without heating, the man throws off belt, wipes it off, cools it down, etc., etc., and in half or three quarters of an hour starts up again. The man's time costs about 20 cents for each stop; four stops a day means 80 cents, besides the extra help and confusion that always comes with a hot bearing. Then, too, the work is delayed and the man is kept from more profitable work. I figure I saved a little by sending that job out, and I shall keep on doing it until you get the new counter for that planer." The counter was ordered that day; the alleged pride of the manager was touched, not by the saving in money, but the thought of doing "all our own work" was too much for one of his narrow gauge in the matter of brain supply. And speaking of this recalls another of the idols that Jones hustled off its pedestal soon after its arrival, and came the nearest to shaking the president's faith in him of anything he ever did. He found them using odd sized set screws, and of course making them in the shop at many times the cost of similar screws ready made, but the idea of "doing all our work" is so pleasing to many that it often covers a big discrepancy in the cost account. A little talk with the president was all that was necessary to convince him of the wisdom of making them all standard, the deluding phantom of being sure of all repair work if they were odd sizes being quite readily dispelled. But he never thought of having them made outside. Having obtained permission to change the sizes to standard, it was an easy step to order a hundred of each kind; but when the bill arrived there was another attack of the "pride fever," which was heightened by the bill for $65.20 which accompanied it. "Why, Mr. Jones, what *do* you mean by such extravagance, to say nothing of our not being able to say we make the entire machine ourselves. Ain't the screws made here good enough for you, or can't you have them made good enough to suit you in this shop?" Jones had prepared for the attack, and kept cool as the proverbial cucumber. "When you built your last hen-coop, which you proudly exhibited in its glory of red and yellow paint, you called it all your own work, though I guess anyone would have known it by the lop-sided angles and unevenly spaced slats; but I noticed you didn't make the *nails* nor even mix the paint. Of course I know you didn't have time, and couldn't have made the nails if you had, and that they would have cost about 20 cents apiece if you tried, of course allowing your time equal to an apprentice's. Well, that's the reason I ordered those screws made. We *can* make them here, but we won't as long as I'm responsible for shop expense. Now here is a half-inch cap screw which no man can turn up in a lathe in less than half an hour, which means fifteen cents for labor, to say nothing about material or the use of the lathe during the time. We buy them for less than five cents apiece all delivered, have no loss from spoiled screws or threads cut 'a leetle small,' and have screws that we can depend on fitting, if they are sent to Kalamazoo or South Africa. I'm sorry to disturb old idols, but I came here to save money for the firm, and when I am held responsible for shop expense, idols of all kinds must go."

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Entered at the Post Office in New York City as Second-class Mail Matter.

MACHINERY,

A practical journal for Machinists and Engineers and for all who are interested in Machinery.

PUBLISHED MONTHLY BY

THE INDUSTRIAL PRESS,

411 AND 413 PEARL STREET, NEW YORK CITY.

ONE DOLLAR A YEAR, - - - - - TEN CENTS A COPY.

FOREIGN SUBSCRIPTIONS ONE DOLLAR AND A HALF A YEAR; POSTAGE PREPAID.

CHAS. CHURCHILL & Co., Ltd., London, Agents for Great Britain.

THE RECEIPT OF A SUBSCRIPTION IS ACKNOWLEDGED BY SENDING THE CURRENT ISSUE.

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WE CANNOT SUPPLY BACK NUMBERS.

OCTOBER, 1895.

THE question of what kind of a finish to put on machine tools is quite a serious one, finish in this case including the grade of work on the moving parts as well as the general appearance of the machine after it receives its final coat of paint. There are men who decry the tendency of the times toward cheaper production on the ground that poorer machines are the result, but with few exceptions the writer believes the reverse to be true. Much of the useless work has been done away with, portions that were formerly polished at considerable expense (and were difficult to keep clean) are now painted, reducing the cost, but not decreasing the effectiveness of the machine. In fact it is quite a study to know what work can be avoided without detriment to the machine, and it is noticeable that there is less unnecessary work put into machinery from year to year. The quality of work, however, is steadily improving in most cases, and a lathe manufacturer told the writer a short time ago that his customers were demanding better work each year. Lathes that were considered good two years ago will not be accepted as first-class machines to-day, and as a consequence he is putting in a better grade of work than before, not simply because he is forced to, but because he has learned to turn out better work and at no advance in price. Better tools enable manufacturers to produce better work than before, and each improved lathe makes possible still better lathes in the future; but back of it, or perhaps in direct connection with it, although too often unrecognized, is the skill of the workman who produces the machine.

* * *

THE ECONOMY OF SPECIALISM.

Few will deny the tendency toward specialism in all industries, and while there may be grounds for objection to it, there is no doubt as to its effect in making labor more effective, or in other words cheapening the cost of production. Nor is this confined to the shop, for it applies with equal force to the drawing room and the office, although the latter application is not as readily recognized. It is, however, just as important that each department of the business should have a head who can make a specialty of his branch, as that one man should run a fox lathe, another a turret, and that a helper should clean the shop, instead of each man sweeping around his own machine; and no one will question the expense of such a system.

The writer was recently in conversation with a leading member of a good sized manufacturing concern, and an inquiry regarding the qualities of a certain machine, led him to say: "I don't know anything about the machine, wouldn't know it if I passed it in the shop, and wouldn't know one end from the other unless the difference was pointed out to me. I don't like machinery, anyway, and I have a man who does know about it to take charge of it, to buy new machines, and I hold him responsible for an economical shop production. As for me, I have all I can do to look after my part of the business, and I don't believe it pays to meddle with work I know nothing about." Needless to say, this firm is doing a good business and has every prospect of success, for realizing the impossibility for one person to excel in all details of the business, these are placed in charge of men who are thoroughly competent, and they are given both the responsibility and the entire control of their departments; features which are too seldom found together. Competent men can give better service when they are given full control of their respective departments, and will willingly accept responsibility in such cases, but they decidedly object to being held responsible for errors committed in their department by others, as is too often done where the head of a concern insists on "managing" every department himself, with the frequent result of not properly attending to his legitimate business, and finds his concern falling behind in economical production. If these men will select competent managers for each department, give them full charge of all that pertains to it, and attend strictly to their own branch of business, they will secure a more economical production and be richer as well as wiser men. It is only by giving a good man entire charge that he can be at his best, knowing that every good move he makes is placed to his credit, and that each unwise decision counts against him by reducing the record of production in his department.

Life is too short for one to become an expert in every department, and even if it were possible it is hardly desirable. It is much better to learn one thing well and make it a specialty than to attempt the unsatisfactory task of trying to manage departments about which one knows but little, and expect the economy which can only be secured by a person thoroughly familiar with it.

ARE THEY PIRATES?

A circular letter from a patent attorney in central New York is being sent to the various papers, together with a lengthy article which attempts to show how manufacturers of patented articles are defrauded of a portion of their trade by those who make repairs for their goods. It is a plaintive tale, but as the author is attorney for a score or more of manufacturing firms, there is a clue as to its purpose. There have been numerous law-suits regarding the repairing of machinery, and, whether in accordance with the last gilt-edged decision or not, it is generally understood that anyone can repair a patented article. If this were not the case, imagine the convenience (?) of losing a bolt from your bicycle when on a long trip and having to walk to town, send to the makers in Kalamazoo for a new one, instead of having one made by the nearest blacksmith. Suppose you break a furnace-grate of a peculiar kind in the dead of winter; how handy, to say nothing of the cost, to wait till the maker in Oshkosh can find an old pattern, have one made and sent by freight, or possibly express, instead of taking the broken pieces for a pattern to a neighboring foundry and having a new set the next morning. And when it comes to cost the alleged pirates are public benefactors in comparison to prices asked by some makers. A friend of mine burned out a set of furnace grates, and in an unguarded moment sent to the *maker* for a new set. After a week's delay they appeared, with a bill that made up for lost time, as they were charged at the rate of *fifteen cents a pound*. This class of castings, which is never even guilty of the touch of a file or emery wheel, in fact the roughest kind of work, are not worth two cents a pound retail, and the *pirates* will supply them for five cents or even less; but we are assured that it is to the interest of all to suppress the pirates. This is all the more exasperating when it is considered that in many cases there are but two or three patents on a whole machine, and yet it is desired that we be inconvenienced to the extent of sending 1,473 miles for all repairs, whether of patented portions or not, because Messrs. Wanto-Makeall-Repairs happened to make the machine in the first place and possibly left some weak points for this very reason. As an example of the "advantage to consumers of buying repairs of manufacturers," it may be well to recall an instance of several years ago in the Northwest. A friend of mine, and the same one who had the fifteen-cent-a-pound grate experience, by the way, was running a little repair shop in a farming district where many reapers and mowers were in use. Some of the small gears had quick consumption, and a few days' running made it a choice between replacing them or buying several larger gear next day. They were rough cast gears, bored and faced, weighing about five pounds, and the price of a new gear was $3.25. My friend made a pattern, had gears cast and proceeded to supply them for $1.25, doubling his money at this price and saving the farmers about two dollars a gear toward the quarterly interest on the mortgage, which seems to be due about twelve times a year. One is forced to recall the lesson in interest where the boy gets it down fine until 100 per cent. is reached, and when he asked about 500 per cent., his father exclaims, "Dot ish not interest, dot ish robbery." It can hardly be claimed in the case of the reaper that these prices were necessary to repay the makers for the cost of experiment and of introducing machines, that should be included in the first cost, and in this particular machine the first cost was $90.00, while reckoning the cost of each part according to repair list, and *putting the machine together yourself*, the cost was in the neighborhood of $600.00.

I do not believe it is in the manufacturer's interest to indulge in such exorbitant money-making schemes, as it makes the maintenance of goods much more expensive than necessary and is not apt to attract trade. Some makers recognize this to the extent of advertising machines that "anybody can repair," and the fact of not being dependent on the manufactory for slight repairs, with the unavoidable delay and annoyance, is of no small importance. It was the idea of requiring all repairs to be sent to the makers that induced the alleged cuteness of making odd threads and sizes, so as to make repair difficult, but instead of getting the repairs they lost the work of making the machines, as no one would put up with the inconvenience for any length of time, and bought other machines. Manufacturers can make parts of a machine much cheaper than any repairer, and if they refuse to supply them at a reasonable price the repairer gets the business—and deserves it. The attempt to force consumers to buy all such parts from the makers is certain to do little more than inconvenience the customer with the result of his going elsewhere for his goods. While, as remarked before, I may not be familiar with the latest ruling on this subject, it is not common sense to expect a man to greatly inconvenience himself in order to keep within the bounds of an arbitrary law which he believes to be unjust; and the tired wheelman on a dusty road cares little whether the patch he puts on his punctured tire (as a tonic for shortness of wind) came from the same factory as the tire itself, or whether it was made from the hide of a Hottentot by some repair man who never heard of any law about repairs or anything else. The more convenient a machine is about repairs the less time is lost by breakdowns, and while the maker may not get so much "repair money" in a year, his machine has more friends, which means that more are likely to be sold. F. H. C.

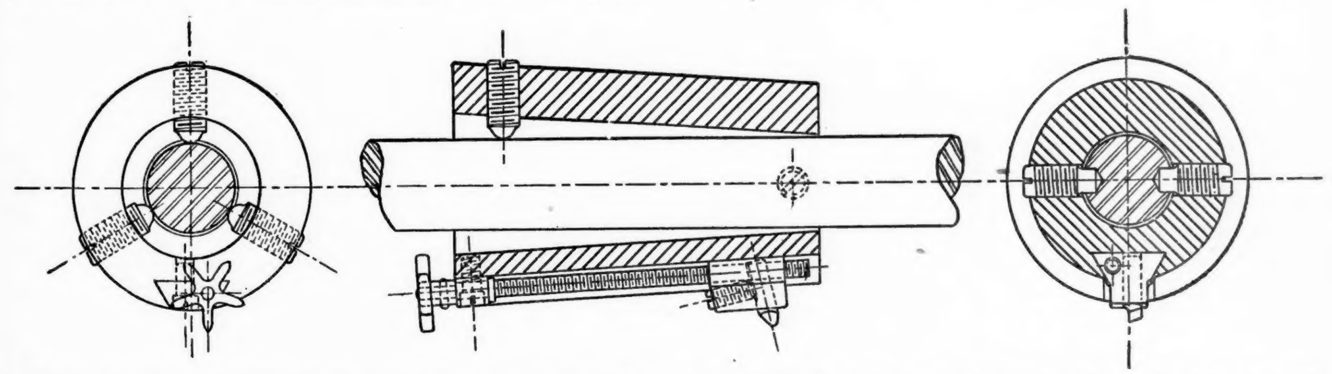
* * *

AN IMPROVED BORING BAR.

J. W. Boynton.

For some of the jobs that come up in the shop it is doubtful if any other boring tool will prove as satisfactory a sone of the type shown in the accompanying sketch. When, for instance, it is required to bore a taper hole in a lathe headstock to receive a taper box; the use of other forms of bar is likely to be impossible or inconvenient. It is probable that a bar of this type would be more generally used were it not for the fact that a bar designed for boring holes of a given degree of taper cannot be used for holes of any different taper. To overcome this objection, the bar shown in the sketch was designed by the writer, and good results have been obtained with it in the shop of Edwin Harrington, Son & Co., Inc., Philadelphia.

The sketch requires little explanation. To permit the angle of



the shell carrying the tool slide to be changed relatively to the axis of the bar, it is provided with a taper hole and attached to the bar by two pivot screws near the small end. By means of the three set screws near the large end the shell may be adjusted and held rigidly to the bar.

A bar of this kind may readily be constructed that will bore holes varying in taper from ½ inch to 3 inches per foot.

* * *

We notice that Mr. H. M. Norris, whose name is more or less familiar to our readers, has accepted the important position of Superintendent and Mechanical Engineer of the Riehle Bros. Testing Machine Co., Engineers, Founders and Machinists, 9th street above Master. This is the oldest established and best equipped Testing Machine Company in the country. Mr. C. E. Buzby, who for a number of years has been their efficient superintendent, is about to retire from active business, but will remain with them in the capacity of Consulting Engineer.

STRENGTH AND PROPORTIONS OF GEAR WHEELS.

J. L. Klindworth.

The frequent necessity for designing gear wheels of great variety, large and small, caused me to collect and examine formulæ for calculating strength of gears which are convenient to use and at the same time reliable. In the following I shall give these formulæ, and also apply them in calculating the strength of a wheel in order to make the article more comprehensible. I have a sort of routine way of working, which is about as follows: Horse power to be transmitted and conditions under which such will be done being known, I usually decide, first, upon shape or kind of tooth, whether cycloidal or involute; 2d, the width of face; 3d, figure for strength; 4th, lay out gear. Beginning with shape of teeth, I shall point out some of the advantages and disadvantages which one system possesses over the other. The most important point which can be made in favor of the cycloidal over the involute system is the fact that a smaller number of teeth may be used in pinion to work into rack, in the former than in the latter. Thus a pinion of 8 or 9 teeth will work very well with cycloidal rack which has $\frac{3}{10}$ pitch addendum (or length of tooth from pitch line to point), but if the same addendum is used on involute rack 20° system, the smallest number of teeth in pinion must not be less than 17. A

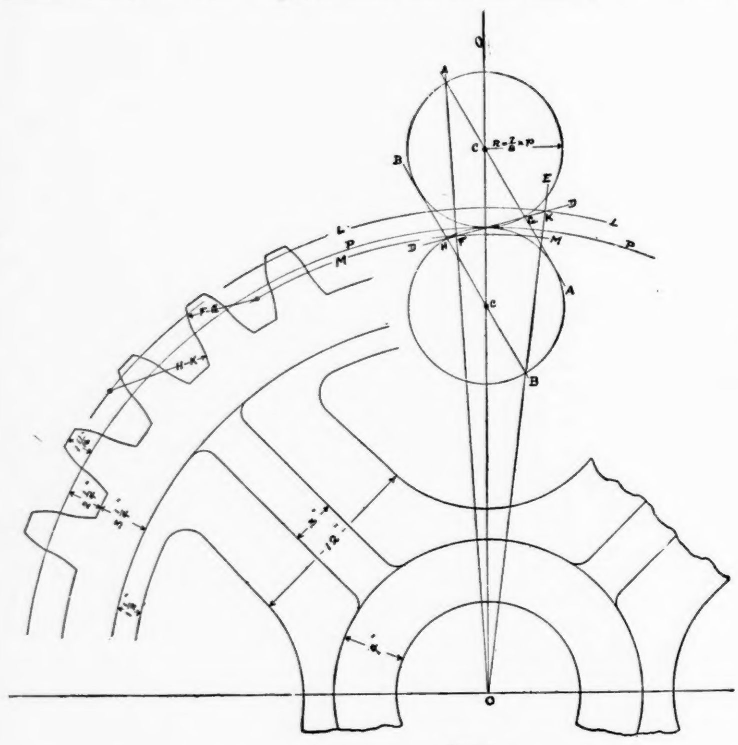


Fig. 2

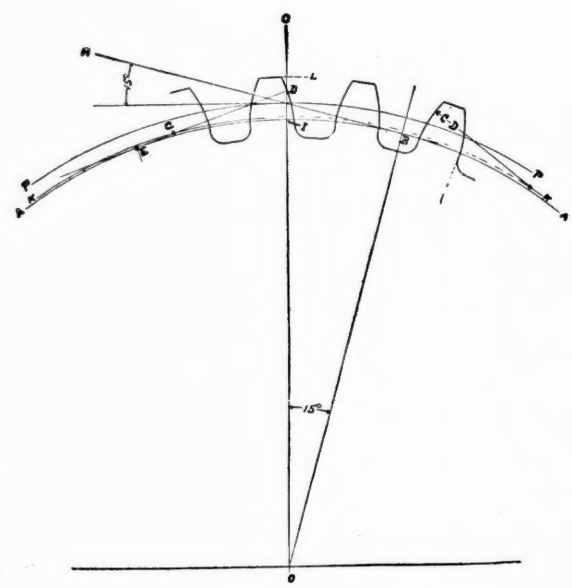


Fig. 3

smaller number, however, may be used if the addendum of the driven wheel be decreased or the angle increased, but the latter is not desirable, as the friction and thrust on bearings is increased thereby. It will therefore be seen from the aforesaid, that where it is desired to have all gears work together, the cycloid system will be the more suitable to adopt; as it enable one to get a high ratio in a train of gearing with lesser number of teeth than by the involute system. As perhaps most readers know, with cycloidal gears it is required that the pitch circles of two wheels touch to insure smooth running. This can be attained in cut gearing, but very seldom in cast gears, especially when of large diameter, and is usually the cause of much objectionable noise by gear wheels. When one, therefore, has to make large gears

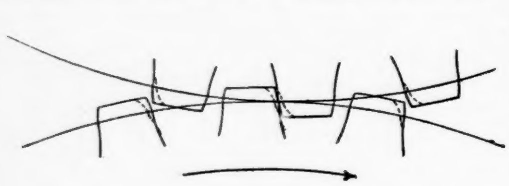


Fig 1

of from 8 to 16 feet in diameter—centers for same being fixed—and thinks of that variable quantity, shrinkage of large castings, it makes one think of some other system of gearing where it is not required that the pitch circles touch each other; and here it is that the involute system comes in, for by it the pitch circles may be drawn apart considerably without causing any trouble, care being taken, however, that not less than 2 pairs of teeth will be in contact at any time. In cycloidal gearing, if distance from pitch circle to pitch circle is not more than about .025 × pitch, the wheels will run with little noise if the shape of teeth is correct.

In regard to strength there is little difference, much depending upon the angle of obliquity in the involute and diameter of rolling circle in cycloidal system. In a general way it may be said that teeth, generated with a rolling circle, the diameter of which is 1¾ × pitch are stronger than 15° and not quite so strong as 20° involutes. More points might be mentioned, but as they are of small importance I shall not enumerate them; the main points are undoubtedly those mentioned above. As regards my opinion about the two systems, I would suggest that cycloidal curves be used for small gears up to about 5 feet in diameter and for larger ones where the centers are not fixed; but where they are fixed I should use the involute system.

The letters used in formulæ* will have the following meaning.

A=Co-efficient of wear.
a=Number of arms.
b=Width of face in inches.
D=Diameter in inches.
H. P=Horse power.
n=Number of revolutions per minute.
P=Pressure or load in pounds.
p=Pitch in inches.
S=Strength of material per square inch tension.
T=Number of teeth.
W=Width of arms at center of wheel.

When width of face is optional I determine it by applying the formula by Reuleaux:

$$\frac{P \times n}{A} = b \quad (1)$$

or pressure multiplied by revolutions per minute ÷ co-efficient A = width of face. The reader will kindly refer to "Face and Wear of Gear Wheels," Machinery, June, 1895. The quantity A may vary considerably according to circumstances, from 20,000 to 56,000 with extreme limit of 70,000. Thus, for a gear that transmits a mean H. P. of ¾ of the maximum H. P., A may be taken 1⅓ times higher than if the maximum H. P. were being transmitted continually. If the H. P., number of revolutions of wheel per minute and diameter are known P may be found from the following formula:

$$P = \frac{126{,}048}{D} \times \frac{H.\,P.}{n} \quad (2)$$

* Formulæ may be found in "Konstruckteur," by F. Reuleaux.

and combining this with formula (1) we have in round numbers,

$$b=\frac{126{,}000}{A}\times\frac{H.\ P.}{D}\ (3)$$

Should the width of face exceed, say 20 inches to 22 inches, it would be advisable to make it in two faces, by putting a half shroud in the middle or increase the diameter.

In calculating strength of tooth, I assume that the pressure or load may at times come on one tooth at or near the point by something dropping between the teeth. Treating the tooth as a beam fixed at the one end and loaded at the other, the formula for finding the load which the beam will carry being,

$$P=\frac{b\,h^2\,s}{6\,l}\ (4)$$

then b corresponds to width of face, h to thickness of tooth, l to length of same. To make this formula more convenient to use, I shall express h and l in terms of pitch. H = thickness, will be about ½ pitch for pinions, and taking .7 × pitch for length we have by substitution

$$P=\frac{b\times p\times p\times s}{6\times.7\,p\times2\times2}=\frac{b\times p\times s}{16.8}\ (4a)\ \text{or}\ p=\frac{16.8\ P}{b\ s}\ (4b)$$

combining (4b) with (1) we have also

$$p=\frac{16.8\ A}{s\ n}\ (4c)$$

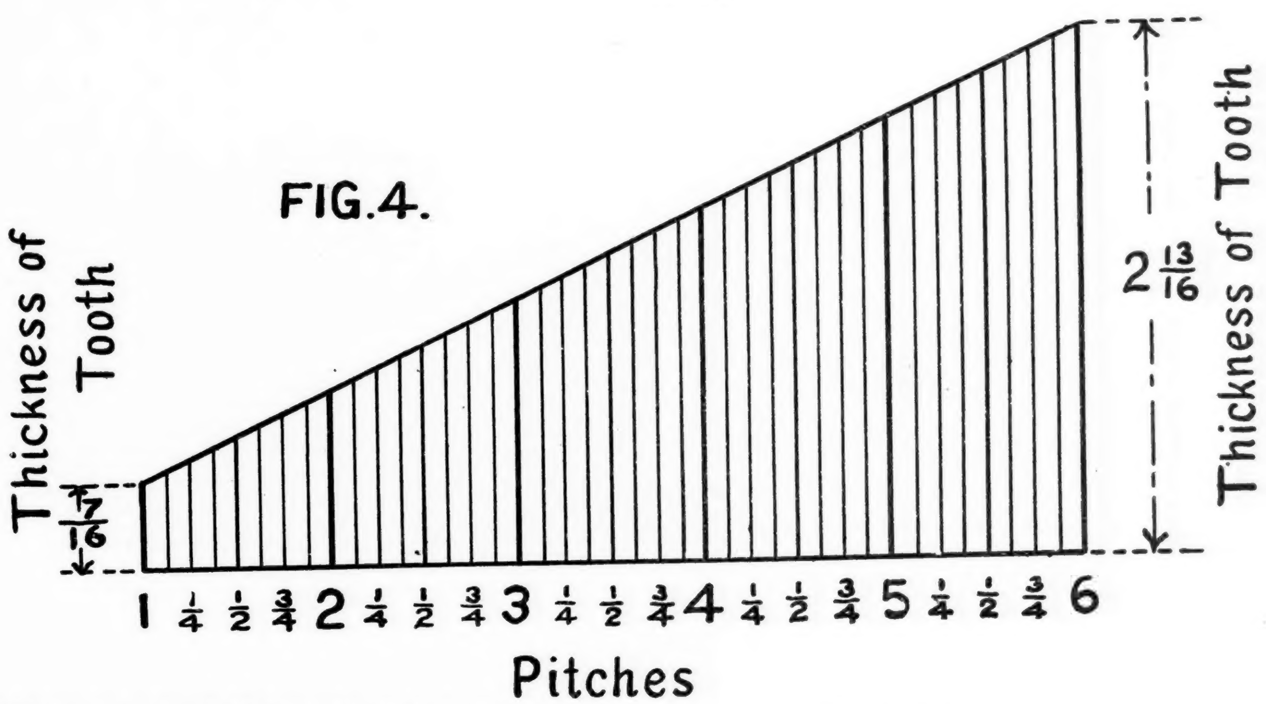
at figure 1, where the full load is supposed to come on tooth instead of being divided on 2 or 3. The dotted lines are to represent the probable wear that will take place (on account of the greater pressure and smaller rubbing surface) and thereby destroy the correct shape of the tooth; consequently will be noisy and work badly. Have made a few wheels with teeth .6 pitch long (.25 pitch above and .35 pitch below pitch line) but always feel a little doubtful as to whether I went in the right direction; should certainly never go below this unless convinced that I could do so with safety. I generally take .7 pitch or the nearest 32d below this for length of teeth.

To show the application of the above formulæ I shall take as an example a wheel of about 5 feet in diameter, which is to transmit a maximum of 400 H. P. and a mean of three-quarters that amount at 100 revolutions per minute. First calculating for width of face, we must decide upon A, the coefficient of wear. Will take it as 50,000, which really is 50,000 × ¾ = 37,500 for the mean H. P. and is well within the limit. By formula (3) we have

$$b=\frac{126{,}000\times H.\ P.}{A\times D}=\frac{126{,}000\times400}{50{,}000\times60}=17\ \text{inches nearly.}$$

Before figuring for strength we must decide upon the allowable stress per square inch of material. The wheel being of cast iron and running at about 1,570 feet per minute, it will not be safe to go much over 1,500 pounds per square inch. By formula (4 c) we have

FIG. 4.



Right here it would probably be in place to touch upon that short tooth. I have read several articles of late in which the good points of a short tooth were mentioned, especially the strength. Just *how short* the writers meant I cannot say, as I do not recollect of having seen any figures. While a short tooth may be stronger, it does not follow that it will work as smoothly or wear as well as a longer one. For smooth working it will readily be seen that two pairs of teeth should be in gear or contact at all times, for if one pair go out of before the next come into gear, the incoming tooth on driver will strike the tooth of the driven wheel (which is retarded by the load) and the breaking of the teeth is but a question of time. In slow moving gearing the effect of such blows would not be very harmful, but when it comes to gearing that runs from 1,500 to 2,000 feet velocity per minute it would soon break the teeth. But a few weeks ago I saw a wheel with very short teeth which had been broken after running but a few months; and although strong enough to do the work, was in my opinion broken by those blows which I mentioned before. The wheel was somewhat over 7 inches pitch and probably about 20 inches face. Formerly the work was done with gears of less pitch but lasted much longer.

As to how short a tooth may be made above the pitch line, so the arc of contact shall equal the pitch, I would say that it must be about 2 pitch for 2 wheels of 11 teeth when diameter of rolling circle is 1¾ pitch; it may be less the greater the number of teeth. The reader may judge for himself in regard to wear by looking

$$p=\frac{16.8\times A}{s\times n}=\frac{16.8\times50{,}000}{1{,}500\times100}=5.6\ \text{inches,}$$

making small allowance for wear, we will call it 5.75 inches pitch. This gives us 33 teeth for the diameter assumed. The correct diameter being, 5.75×33×.3183=60.39 inches. Summarizing we have: Wheel 33 teeth, 5.75 inches pitch, 17 inches face, 60.39 inches diameter to transmit 400 H. P. at 100 revolutions per minute. Thickness of rim, width of arms, etc., I usually determine after having drawn the teeth, which, if cycloidal, I do by Prof. Reuleaux's method shown in Fig. 2 and is as follows: From O as center describe pitch circle P P, draw line O O with radii ⅞×p and centers C C on O O draw rolling circles touching each other on line P P. Through C C draw A A and B B, draw D D through the points where A A and B B intersect circles, draw O A and O E, through points F and K where lines O A and O E intersect D D draw circles L L and M M; then the distance from point H to K on line D D will be the radii for tooth curve below, and from point F to G for tooth curve above the pitch line; the centers for radii being located on circles L L and M M as shown in figure. Besides being simple, this method gives very close approximation to the true cycloidal curves. Have used it for four years and found it satisfactory for all purposes. The only modification that I make is in taking radii F G, or face radius, a little less and radii H K, or flank radii, somewhat greater than the rule given. This I do mainly for the reason that the casting does

not always come out as true as the pattern, and if this precaution is not taken the points of teeth may not enter as they should, this holds good especially for pinions from about 15 to 11 teeth and less, where the deviation of the curves from the true cycloids are more pronounced. If possible I always make drawings of teeth full size, as greater accuracy is attained thereby.

For drawing involutes I use the method given by Unwin in his "Elements of Machine Design," Vol. I. See Fig. 3. From O as center, describe pitch circle P P and through its point of intersection with line O O draw H B, next draw O B, then O B is radii of base circle, draw base circle A A. Make I D = ⅔ I L, through D draw tangent E D to base circle. Take C D = ¼ E D and with C as center on line E D draw tooth curve from point of tooth to base circle. From base circle to base the teeth are radial. For convenience circle K K may be drawn through C, from which all curves are struck. This method is very good and may be used for all angles of obliquity.

Proceeding now to draw the wheel mentioned above, we draw the pitch circle and circles for length of tooth above and below the pitch circle. Step off pitch on pitch circle also thickness of tooth and draw teeth, say by Reuleaux's method. The thickness of tooth is usually expressed in terms of the pitch by the different writers, this does not seem altogether the right thing, for it gives very small side clearance for fine, and almost excessive clearance for coarse pitches, which allows of so much more back lash. Would recommend making a diagram something like shown in Fig. 4 for ascertaining thickness of teeth. The pitches are laid off on base line and the vertical give thickness of tooth. Thickness of rim I make from .5 p to .6 p, depending upon the width of tooth at root and number of arms in wheel, in this case about .56 pitch. When the arms has a cross section I make the thickness of rib about the same as rim or a little lighter and width at center=

$$W = p\sqrt{\frac{T \times b \times c}{a \times \text{thickness}}} \quad (5)$$

where c may be made .09 for ordinary gears, and up to .11 for gears that will be subject to considerable shocks. For the wheel in question,

$$W = 5.75\sqrt{\frac{33 \times 17 \times .1}{4 \times 3}} = 12\tfrac{1}{2} \text{ inches nearly.}$$

A taper of from ½ inch to ⅝ inch per foot may be given the arms. The hub will be strong enough if made twice the diameter of shaft and length equal to width of face for small gears up to about 5 feet diameter; for wheels of larger diameter length of hub should be from 1.2 to 1.3 times face. It sometimes happens that the shaft upon which the wheel is keyed is larger than the diameter necessary for torsion, it will then be well enough to take the formula for shafting given in the January number of MACHINERY,

$$\text{Diameter} = \sqrt{\frac{\text{H. P.} \times 100}{n}}$$

and adding the diameter thus found to the bore of the wheel the sum will then be the diameter of hub.

In conclusion would like to add, that the formulæ given above apply to straight toothed, cast iron gears. For helical teeth A may be taken higher than given above, because the pressure normal to the tooth surface is less. For steel gears A may be taken 1.5 times greater than for cast iron.

* * *

THE CALCULATING MACHINE.

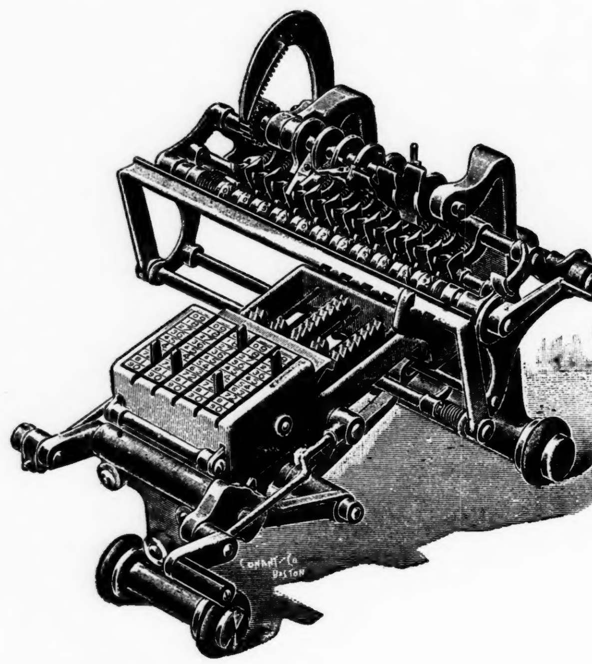
GEORGE B. GRANT.

Europe is using the calculating machine, and has at least three large concerns engaged in the manufacture, but this country is still lagging behind and doing its figuring with brain and pencil. A few hundred of the foreign machines have been imported at great cost, for the use of large concerns and government offices, but our mercantile and industrial business is still without this great aid to efficiency, accuracy and mental ease.

Twenty years ago I made the first attempt to put an American calculating machine on the market, and, in 1876 and 1878, succeeded in selling a few instruments, but the price was high, capital was lacking, the public was indifferent, and I had to abandon the attempt. Shortly afterwards Baldwin, of Philadelphia, made a similar attempt, with the same result from the same causes. Since then nothing has been done in this country, except in the way of adding machines, and the public have been obliged to pay the high cost of the imported instruments or go without any.

I am now working in the same direction and this time believe I have produced a machine that is not only cheap enough for ordinary mercantile use, bnt also quite as efficient as and much more durable than the foreign instruments.

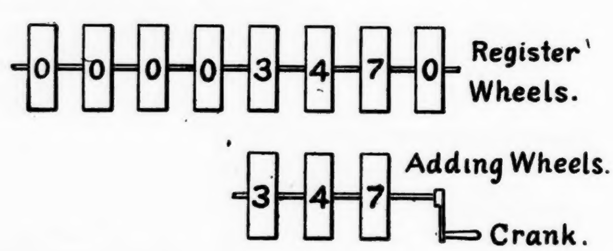
The engraving shows the machine in perspective and I will explain its operation as clearly as is possible in this place.



The calculating machine, to be of general utility, must not only add but multiply and divide. We can produce adding machines of various forms, but to produce a real calculating machine we must follow, in a general way, the principles first put into working shape by Thomas de Colmar, about the year 1850. At least, nothing but feeble slide rules and limited adding machines have so far been produced in any other way.

Multiplication is a compound form of addition, and division is a compound form of subtraction. As subtraction is a form of, a simple reversal of, addition, we can reduce the four rules to addition alone, and Colmar's invention is a device by which addition is so handled as to result in either operation.

Thus, to illustrate the Colmar scheme in outline, we have a series of register wheels, and, in front of them, a series of adding devices. The set of register wheels can be moved to the right or to the left so that the series of adding devices will act on any of the wheels. The adding devices are of any form, and there are many to choose from, that can each be set to a given figure and will turn the opposite register wheel through as many teeth as it is set to every time an operating handle is turned.



For addition we have simply to set the adding devices to the number to be added, turn the operating handle once, set up the next number, and proceed in that way as far as may be necessary.

For subtraction there are two methods. Colmar used a special device by which his adding wheels worked backwards, and turned the register wheels backwards, but a simpler method is to so set up the number to be subtracted that its arithmetical complement is added instead, as is easily accomplished with special mechanism.

For multiplication we turn the operating handle as many times as the number set up on the adding devices is to be multiplied. Thus, to multiply 347 by 5, we set up 3, 4 and 7, and turn the crank 5 times. We then shift the register wheels along one figure and use the second multiplier figure in the same way. The process is clearly shown by this detail,

```
      00000
       347
       347
       347 5 times.
       347
       347 shift.
      347 3 times.
      347
      347 shift
     347
     347   2 times.
   81,545 product.
```

the number 347 being thus multiplied by 235.

Division is somewhat more complicated, and consists in continually subtracting the divisor until it is seen that it can not be subtracted again, the quotient being the number of times it is subtracted. This process may be thus detailed, to divide 81,545 by 347,

```
81545 dividend.
347   sub. 1.
46845
347   sub. 2.
12145
```

now, as 347 can not be subtracted again, the first quotient figure is 2 because we have subtracted the divisor twice. To get the second quotient figure shift the register wheel along and try again,

```
12145
 347  sub. 1.
08675
 347  sub. 2.
05205
 347  sub. 3.
01735
```

the quotient being 3 because we have been able to subtract 3 times.

I will not attempt to describe the Colmar machine, for that would be a great undertaking by itself. The process, to describe it, is simplicity itself, but, carried out in mechanism, it requires a multitude of wheels, pawls, gears, slides, etc., a machine to use eight adding wheels and sixteen register wheels having about a thousand separable pieces. Most of these parts are small and many are very delicate, and it would be a hopeless undertaking to make such a machine in a durable manner at a reasonable price. The machines made by the original Colmar concern, in Paris, are fragile and easily worn out. A concern in Saxony makes a machine that is a copy, item by item, of the Colmar, but absorbs the reputation of that invention under the name of Burckhardt, selling a machine that is more finely finished but quite as poorly made and as fragile. A concern in London, Tate by name, makes a machine that is also a copy of the Colmar but very much better made and more durable, and, consequently, much more expensive. The cost of these instruments is from $150 to $375, quite out of the reach of an ordinary business office.

As stated, every practical calculating machine must be arranged on the Colmar plan, but the mechanism may be of several different varieties. There are many plans shown by the literature and patents on the subject, but most of them are simply changes in the arrangement and unimportant details of the Colmar mechanism, and those that are different are seldom any improvement upon it. It is no improvement to reduce the number of parts, if you thereby decrease the efficiency of the instrument.

The engraving shows the set of eleven register wheels on a shaft at the back of the machine, and that shaft is carried by a frame that slides laterally upon the main frame of the machine. It is fixed in either one of six positions by a latch seen in front of the register wheels.

The set of five adding devices is carried by a frame that is reciprocated by the operating crank seen at the front and right of the instrument, going back about two inches and returning at every rotation of the crank. These are racks which slide on rods set in the reciprocating frame, and each has a setting pin projecting through a slot in the frame. By moving the setting pins to the figures beside the slots we set them to read any number desired, 22827 in the engraving. As the frame is thrown forward by turning the crank, each rack will engage with and move the opposite register wheel and rotate it a number of teeth equal to the setting of the setting pin. If a pin is set at 0 the rack will be so placed that it will not strike the opposite wheel at all; if it is then set at 1, the rack will be one tooth further forward and will move the register wheel over one tooth; and, if it is set at 9, the rack will strike the wheel about as soon as the frame begins to move and will throw it over nine teeth. Thus, one turn of the crank will show the wheels moved to 22827.

When the adding frame reaches the end of its movement backward, a cam, seen on the crank shaft in front, will raise all the register wheels a little by tipping the register wheel frame so that the wheels are disengaged from the racks and are not moved during the return motion. Therefore the first part of the Colmar movement is accomplished, and the number set up by the pins is added to the number on the register wheels at every rotation of the crank.

To carry the tens from any register wheel to the next we see a set of carry teeth arranged in a spiral on a shaft over the wheels. This shaft oscillates in unison with the adding frame and the teeth will engage with the register wheels and turn each one through one tooth whenever a carriage is required, during the return motion of the adding frame.

This is about the whole of the mechanism, all parts being exposed to view and shown by the engraving. Its operation will be readily understood if the above description of the Colmar process is followed out carefully, for the machine differs from that instrument only in mechanism

With regard to the utility of the machine, its success proves that it saves not only time, but greatly increases the accuracy of arithmetical work, and saves about all the mental labor and worry.

In the process of addition the machine takes the work that usually taxes the brain the most, the summing, and the carrying of tens. The operator who is familiar with the machine will find the work so mechanical and free from thought in any form that he can think of some other subject while his eyes and fingers do all the work.

In the process of multiplication the whole multiplication table, as well as all the adding and carrying is done away with, and the operator simply has to read his numbers and set them up correctly and turn the crank as required. He can look out of the window during the greater part of the operation, so simple and easy is it. All computers know and value the logarithmic method, but we have the best of disinterested authority for saying that mechanical multiplication is not only much easier, but twice as accurate, and more than twice as rapid as that invention.

On division the mechanical compares with the mental process about as for multiplication. The quotient is obtained by watching the register wheels and noting when the decreasing dividend is smaller than the divisor, a very easy operation. Long division is robbed of its terrors.

Those who do not know the machine are stubborn, as always with humans, and prefer the pencil, and many who are opposed to mechanism, are as opposed to it as they are to the typewriter. But the croakers may croak and the ignorant are dying off or being converted, and the calculating machine will come into use as one of the most valuable of labor saving devices. A few cannot afford it, because their time is so cheap they find it cheaper to labor with their heads and a lead pencil, but the greater part of the objection comes from ignorance and time will wear that out.

The machine is made by the Grant Calculating Machine Co., of Lexington, Mass.

* * *

LINING UP SHAFTING.

Robert Grimshaw.

In lining up shafting the problem is to get the line not only straight but level. A line may as a general thing be straight, without being level; that is, a center-line drawn through the whole system might pass through the exact center of every section and yet one end might be higher than the other. It might be level without being straight; thus each section might have kinks in it, or the whole line might be bowed in a horizontal plane; yet it might all show up perfectly level by any system tried.

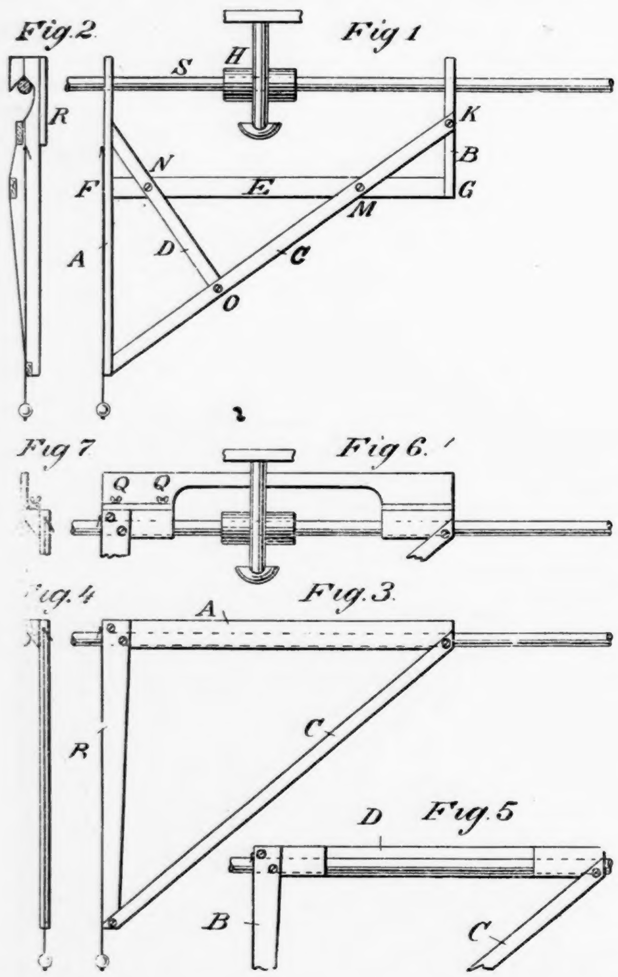
There are two ways by which the level of a line may be found, and if not level, by which it may be made so. One is by the water or spirit-level and the other by the plumb-line.

Whatever method be employed, it must be available for every kind of a line that one is liable to find; that is, those which have great distances between hangers, and those which are very much interrupted by them.

At present I shall show a few ways by which the plumb-bob is used. We shall have to assume that we believe, or rather know certainly, that a level line or plane is at right angles to a vertical

line or plane and that a plumb-line is a certain method by which to ascertain the verticality of anything already erected, or by which to erect or adjust anything absolutely vertical.

Referring to figure 1, in which S is a line of shafting presumed to be already erected as nearly level as the eye can tell, and H one of the hangers; we have here a device by which the line on both sides of the hangers may be leveled at once; and of course, the same appliance may be and should be set up between hangers. A and B are two pieces of board each of which has a lengthwise center-line scribed thereon; and has also portions cut away so as to leave notched pieces, truly centered, and both alike, by which these pieces may be hung from the shaft. These notches are made correct by the two pieces being screwed together and a truly-centered hole with a diameter within two inches of the width of the boards made through both at once. Then tangents are drawn and the sides of the hole, at equal angles with the center-line, and the stuff is cut away so as to present the appearance shown in the end view, Fig. 2. The longer A is, the better; B may be about two feet. Brace-pieces C, D and E are then made, and E is first attached so as to be as nearly as possible square with both A and



B, which two should then be parallel. One screw is used at each of the joints F and G. Then C is attached to B by one screw at K, then it is attached to A at B by one screw, after A and B have been brought absolutely square with E. This being done, one screw is put at each of the places M, N and O, a distance-piece as thick as brace E being required at M. When the frame is thus pinned together, it should be absolutely rigid, and the squareness of the working edge of A (that shown to the left) with the upper or working edge of E should be well tested. This being done, if the system is hung on the shaft as shown in Fig. 1, a plumb-line suspended along the working edge of A will show this edge to be absolutely vertical if the shaft is absolutely level. It is well to check the accuracy of this (1) by sliding the device along the shaft from one end to the other, skipping the hangers and couplings when they are encountered, and then (2) running it along the line in the same way, the other way too; that is, with the working edge towards the other end of the shaft.

To make the plumb-bob come to rest more quickly than it otherwise would, it may be allowed to hang in a bucket of wa r. *A* may be strengthened where cut away by a reinforcing strip R.

A variation of this device is shown in Fig. 3, in which *A* is a piece of four-by-four-inch scantling along which a lengthwise center-line has been scribed, top and bottom, and in which an angular groove has been cut, truly parallel with these center-lines. This work may be done on an ordinary pattern-maker's saw-bench. Then a piece B, with one perfectly straight working edge, is screwed to A absolutely at right angles to the top and bottom edges of A. A brace-piece C extends from A to B; and the plumb-line is hung along the working edge of B as shown in the sketch.

Instead of having long, heavy pieces of scantling, say six feet long, as shown in Fig. 3, a two-foot piece may be scribed, grooved and then sawed across in two, and the two pieces joined in true parallel by a lengthwise piece D, then the piece B is made square with the joined grooved pieces, and the brace C put in to keep them stiff. If necessary another brace, E, may be screwed between A and C.

All three of these devices may be unscrewed so as to make them take up less room in storage, but before doing this, all the parts should be marked, and the screws should be coated with a mixture of graphite and tallow and tied up in a paper that is fastened to one of the pieces. Then all the pieces should be fastened together.

Any of these three rigs may be used with a level to check the accuracy of the plumb-line, if desired.

The second and third styles cannot straddle hangers very well; but the third one can be made to do so by a slight modification as shown in Figs. 6 and 7; and where a hanger is of an especially difficult pattern to "get true" the connecting-piece may be attached to one of the grooved pieces by thumb-screws at Q Q.

* * *

RALPH HART TWEDDELL.

The sudden death of Mr. Ralph Hart Tweddell on September 3d removes another shining light from English engineering circles, although the influence of his work was not confined to that country. To him, perhaps more than to any other man, is due the advances in the application of hydraulics to machine tools. After serving his apprenticeship with Messrs. R. & W. Hawthorn, Newcastle-on-Tyne, he superintended the construction of the boilers and engines of a Turkish steamer, and during this work his ideas on hydraulic riveting took shape. Its great success in 1863, when Mr. Tweddell was but twenty years of age, led to a wide application of the system to other machine tools. About two years ago he was awarded a medal by the Franklin Institute, of Philadelphia, showing that his work was also appreciated on this side of the Atlantic.

* * *

THEY ARE PATENTED.

We are informed by the Builders' Iron Foundry that the belt shifter which was illustrated in the September number as the product of Messrs. Armanrie & Co., of London, England, is an infringement on a patent granted to Mr. Frank A. Shoemaker, of Buffalo, N. Y., in 1887, controlled by the first named concern. We mention this to prevent any difficulty arising from its use by parties who did not know of the American patent.

We are also advised by the Franklin Portable Crane and Hoist Co., Franklin, Pa., that the portable crane illustrated in connection with the Westinghouse Electric Company's shop in our September issue, comes within their patent claim and will be protected by law. Our correspondent supposed it to be a home made affair and being impressed with its usefulness made a rough sketch; the question of patent never occurred to him.

Whether patented or not, it is a good thing and will be appreciated by machine shop managers who can communicate with the above company if they wish to be on the safe side.

* * *

Mr. John A. McGregor, formerly assistant superintendent for Brown & Sharpe and later a member of the firm of Edwin Harrington, Son & Co., of Philadelphia, Pa., has resigned this position to become general superintendent of the Morse Twist Drill and Machine Co., at New Bedford, Mass. From a personal knowledge of his work in the improvement of machine shop methods we feel that the latter company are fortunate in securing his services.

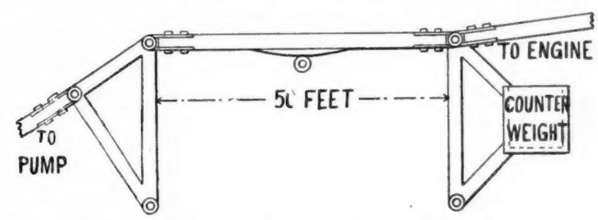
A JAUNT IN JERSEY.

FRED H. COLVIN.

ONE seldom thinks of New Jersey as either mountainous or an iron region, and yet the writer found both to be the case in a little trip made between a Saturday and a Monday in the month of August. Leaving New York on the D., L. & W. R. R. (which can be interpreted according to the reader's acquaintance with the road) at 12.30 P. M. of a pleasant Saturday, the train passes Newark and begins its climb through the Oranges and the pretty country beyond, till Summit is reached, when the climbing is changed to "coasting," and at 1.49 Rockaway is reached. Here is one of the interesting features connected with the old canal system, in the shape of "Plane No. 8" of the Morris & Essex Canal. There is a difference of perhaps 75 feet between the height of the upper and lower canal at this point. Instead of "locking" from one level to the other, which would be an expensive construction and use large quantities of water, there is a primitive ship railway with a cradle-like car, which carries the canal-boat on its overland journey. The accompanying photograph will give an idea of the plane, the tracks being perhaps 12 or 15 feet gauge and having a central cable as shown, which returns on sheaves between the plane and the sluice-way, which

supplies the lower canal from the overflow of the upper. The car was enjoying a bath in the top canal at the time, with the main object of keeping its old (and presumably rheumatic) joints from being affected by the heat of the sun. This is one of the simplest affairs I know of for getting the boats where they are wanted. The upper canal simply ends at the top of the plane, no locks or gates, but just comes to an end. The track is laid up the plane, and breaking over the brow of the hill again descends into the upper canal as far as necessary to get the required depth to enable the boats to float into the car, the lower end being similarly laid into the lower canal. Power for hauling is obtained by a turbine set in the sluice-way shown, which gives all the hauling capacity required.

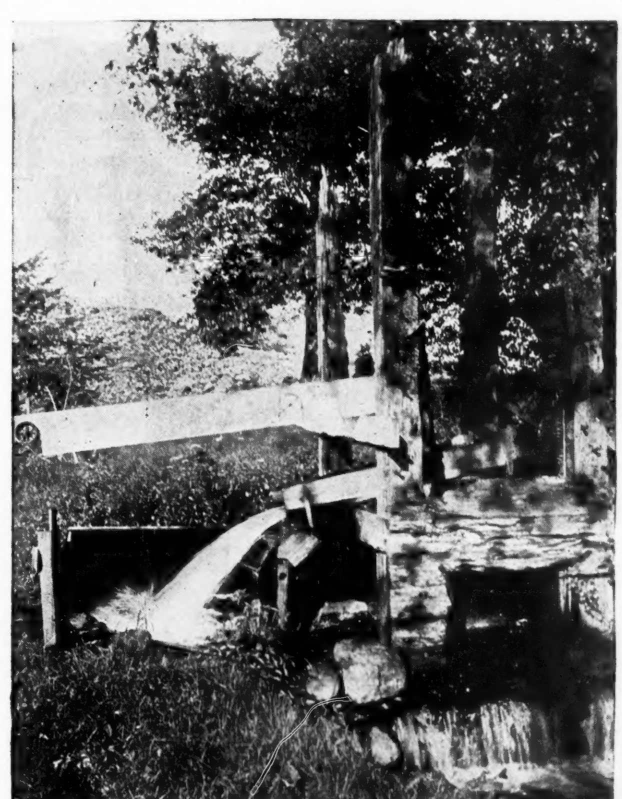
A carriage drive of four miles takes one to Dover, where the car shops of this division of the road are located, but as it is Sunday there is no object in visiting them, and a few miles more brings Port Oram in view. Here is an iron furnace in operation, and it is credited with quite an output, its iron going to Easton and vicinity. A little further on and an old pump-house, from which steam is escaping, attracts the eyes, and an examination reveals a mine pump of the old pattern, which is briefly outlined in the accompanying sketch. The beam connecting the two bell cranks was perhaps 50 feet in length and 10 by 14 inches cross-section, of heavy timber, with iron straps at the ends for retaining the boxes. The idler for supporting the center of the beam is rather an ingenious arrangement, the curved piece below the beam being shaped to bear on the pulley in all positions of the beam, taking care of the rise and fall due to the arc described by the upright arms of the bell cranks. The counter-weight was a strong box of possibly 6 by 6 by 7 feet, filled with ore and junk in various assortment. The pump-rod was at an angle of about 30 degrees from the horizontal. This bit of antiquity, with its creaking joints, led one to expect an engine of the same type, with a gun-barrel cylinder and six months' stroke, and it was more than a surprise to find a new tandem Corliss by the C. & G. Cooper Co., of Mount Vernon, Ohio, which was trying hard to keep itself awake at about twenty-five revolutions per minute. There was a heavy fly-wheel, perhaps twenty feet in diameter, which prevented the engine stopping at each end of the stroke



until it was time to go on again. A heavy pinion on the crank-shaft geared to the pump-shaft at four to one, the pump making about six (plus) strokes a minute. The economy of placing such an expensive engine for this duty is to be questioned from several points of view, and can be estimated according to the views of the observer. How old the pump end of the combination was, I was unable to learn, as it was older than the memory of man—at least the man in charge.

From here the road leads to the Government Powder Depot (which, in my lack of historical knowledge, I never knew existed), where is stored in houses far apart, tons and tons of powder with which to escort somebody out of this world should occasion arise. The grounds must cover at least ten square miles, including hill and dale, a long narrow lake with plenty of fish, and as there is no hunting allowed, owing to the danger of fire and explosion, much game is literally driven in from the outside.

In the grounds, by the lower end of the lake, is the remains of an old forge, the photograph showing the overflow of the old sluice-way and a portion of the old water-wheel, which was probably used to blow the bellows for the forge. This was used many years ago, and in this connection it is well to remember that in these same mountains, about six or eight miles from here, at a lake called Split Rock, were some of the old forges of revolutionary fame, where cannons and ammunition were made, using the native ore and working it into these heavy castings. Here they were practically safe from the British, as they were quite inaccessible, and a few men who knew the mountains could keep a large



force at bay. If any of the readers of MACHINERY want to enthuse and poetize, they can find no better place than this locality, for the stores of powder, the old forges, the "mountain fastness," etc., should afford plenty of ammunition for the poetical gun. Even the writer, in spite of the buzz of gears (not

wheels) and the sound of the shop in his head, was tempted to try his hand, but didn't, for various reasons. On the way back to Rockaway we passed through Mt. Hope, also a mining and smelting town in the years gone by, and the remains of several furnaces can be seen. Old engines, standing like monuments on the pedestal of a solid foundation, the outer walls having fallen long ago, give the foundation builders a good recommendation.

If the extent of the mining industry that formerly existed can be judged by the amount of abandoned iron cable, used to hoist cars up the shafts and draw them up the planes, it must have assumed large proportions. There are miles of this cable to be seen along the road, being utilized as a sort of mammoth wire fencing, and when substantially fastened, three high, to posts and trees, makes a very good fence. Some of this had been doing duty in this manner so long that it was completely embedded in the side of the tree, the growth of the latter having slowly but surely embraced it in a grasp that dlscounts the staple ordinarily used. The return to Rockaway was only made eventful by the dog suddenly stopping in front of the carriage with his foot in the wheel track, resulting in a lame foot and a dog in the carriage the rest of the way home.

* * *

COUNTERBALANCING.

W. H. Booth.

In the article on Counterbalancing which appeared in August there was an omission of sufficient reference to the Figs. 1 and 2.

In Fig. 1, which represents the case for the outside cylinder locomotive, the crank-pin *a* is balanced by a heavy weight B in its own wheel, and a lighter weight *c*, shown dotted, being supposed to be in the opposite wheel. The opposite crank-pin *d* is similarly balanced by a heavy weight *e* in its own wheel, and a light weight *f* in the other wheel. Thus in the side of the engine on which is crank *a* the wheel contains two weights, B and *f*, found as described, and if we join these by a line as shown and make B G proportionate to the weight *f*, and *f g* proportionate to B, and at *g* put a weight equal to the sum of the weights B+*f*, then will *g* be the correct balance weight for the crank *a* both in quantity and direction. The weight *g* may be moved out along the same radius line to some point nearer the rim, but if so it must be made less in proportion as it is moved outwards.

In Fig. 2 we have the case for the inside cylinder or cranked axle. The crank *a* is balanced by *b* in one wheel and *c* in the other, both weights being opposite the crank, and the crank *d* is balanced by the two weights at *f*. Thus in one wheel we have *b* and *f* and in the other *c* and *f*, and the weights *g* and *h* are respectively the equivalent single weights for the cranks *a* and *d* as indicated by the arrows *o n*: the crank *a* leading its balance and the crank *d* following its balance.

If we wish to take into effect, as we should do, the valve motion, we must find the angularity and throw of the eccentric likely to be used at the highest speed of engine and on one of the Figs. 1 or 2 lay this off exactly as if it were another crank, and find the necessary weights to be placed in each wheel. This

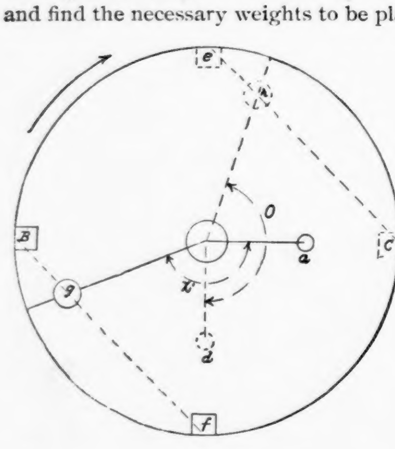


Fig. 1

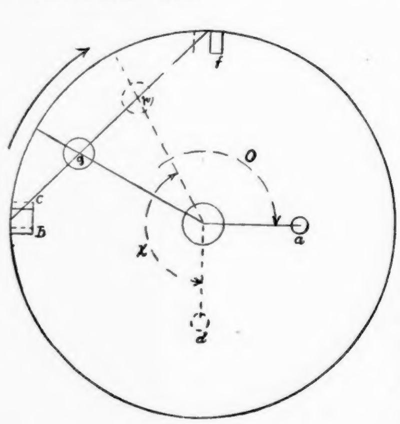


Fig. 2.

done find the equivalent single weight as in the case of the crank. We now have two equivalent single weights, one for the cranks, the other for the valve gear. Join the two equivalent weights and divide the joining line in the inverse ratio of the two and the point found will then be the equivalent weight to be placed in the wheel to balance all the disturbing forces we have let into the calculation. In this way we can reduce the balance for any number of revolving weights at any distance from each other to one equivalent single weight in the two wheels, and we can do it by dealing with each disturbing weight separately until we get, if we like, fifty separate balance weights in the circle of each wheel. Any two may be resolved into a single one, and the equivalents thus found gradually paired and paired till one weight only remains. Every pairing will of course bring the equivalent nearer to the center of the wheel, and for accuracy when the radius becomes small it may be extended and the weight correspondingly reduced, and this may be done with any one of the weights and with any equivalent and at any period of the investigation. Sometimes with a system of weights it might happen that the two final equivalents were equal. and on opposite radii of equal length. This obviously implies a final equivalent upon the very center, which means that the disturbing forces are at a balance among themseves, and no counterbalance is therefore required.

* * *

THE FIRST PRINCIPLES OF MECHANICS.—1.

Lester G. French.

Mechanics is that branch of science which treats of the action of force, and of its effects. A *force* is commonly defined as any cause tending to produce or modify motion. Its action is always equivalent to a push or a pull, such as is exerted when we use our muscles, and until we have made some progress in the study of the subject, it will be simpler to consider force in this sense, simply, without regard to its effects. For the present, therefore, a force may be defined as any cause producing a push or a pull. There are many familiar examples of force, as muscular effort, gravity, the expansive force of steam, the elasticity of a spring, the attraction of a magnet, etc.

The unit by which force is usually measured is the standard pound, avoirdupois; that is, the common pound. A force of 100 pounds is one capable of sustaining a weight of 100 pounds. It will appear hereafter that the weight of the pound varies with the locality, so that this unit is not an absolute one. The variation is so slight, however, that it is of no consequence, except in very accurate physical investigations.

MATTER.

The material of which anything is composed is called *matter*. The term is a collective one, and is used when no particular substance is referred to. Lead, iron, water, air, or any other substance is spoken of in a general way as "matter."

Matter exists in three states: the solid, the liquid and the gaseous. A *solid*, of which wood and iron are examples, is characterized by a tendency to resist any attempt to change either its shape or size. A *liquid* readily changes its shape, but its volume or size remains constant under the same temperature conditions. A pint of water will fill a pint vessel of any shape, but it cannot be forced into a vessel holding less than a pint*. A *gas* has neither definite shape nor definite volume. It will accommodate itself to any shape, like a liquid, can be compressed easily, and will also expand into a larger space. Air, oxygen, nitrogen and hydrogen are examples of gases.

Since force can act upon all three forms of matter, the subject of mechanics is divided into the mechanics of solids, the me-

* Liquids are very slightly compressible. Water will diminish about .00005 in volume under a pressure of 15 pounds per square inch.

chanics of liquids, or hydraulics, and the mechanics of gases, or pneumatics. For the present, only the mechanics of solids will be considered.

A *body* is a definite portion of matter, as a pound of lead, an iron bar, a quart of water, or a cubic foot of air.

It is believed that all bodies are made up of extremely small portions of matter, called *molecules*, which are separated from one another by distances that are great compared with their size. These molecules are so minute that it is impossible to detect them, even with the most powerful microscope; but there are many facts determined by experiment, that make their existence seem very probable. If the speculations of scientists are correct, at least 500,000 molecules could be placed in a row between the measuring surfaces of a micrometer caliper, when it is set to read .001 of an inch. A molecule is the smallest portion of matter that

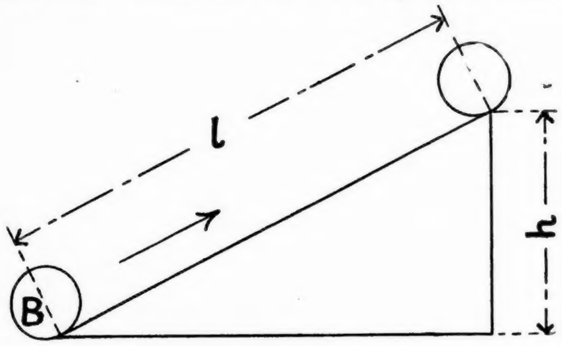


FIG. 1.

can exist and still retain the properties of the substance of which it is a part.

It is believed, further, that every molecule contains two or more indivisible portions of matter, called *atoms*. Thus a molecule, of water is composed of two atoms of hydrogen gas and one atom of oxygen gas. A molecule can be separated into its atoms by chemical action only, and then the separation is only momentary, for the atoms at once combine to form other molecules, usually of a different nature. The atom is purely a chemical unit; we are not concerned with it in mechanics.

MOLECULAR FORCES.

Two opposing forces reside in the molecules,—an attractive force that binds the molecules together, and a repellent force, that tends to push them apart. The three states of matter, solid, liquid and gaseous, depend upon the relation of these forces. If the attractive force predominates, the body is solid; if the repellent, it is gaseous; if the two are nearly balanced, it is liquid.

The repellent force is probably one manifestation of the phenomenon which we call heat. Thus, when a bar of steel is heated, the attractive force is gradually overcome by the repellent force, as is seen in the expansion and finally in the melting of the bar. So, also, if we heat a piece of ice, the ice is turned to water, and at last, when the repellent force becomes very strong, the water is turned into steam.

The attractive force is capable of acting not only between molecules of the same kind and in the same body, but between the surfaces of different bodies which are in contact, as well. In the former case it is called *cohesion* and in the latter *adhesion* It is cohesion that resists any attempt to pull apart a body, like a string or a wire, and adhesion that holds together bodies that stick to one another, as in the case of two pieces of wood, when united by glue, or of drops of rain on a window-pane, pencil or ink marks on a piece of paper, etc. The effect of adhesion is usually more noticeable between solids and liquids than elsewhere. Neither force will act, except at insensible distances. To join two pieces of iron, for example, welding must be resorted to, in which process the hammering brings the molecules in the two parts near enough together for the cohesive force to take effect. Adhesion and cohesion are of the same nature, the difference between them being one of name or definition rather than of kind. Two absolutely smooth surfaces, if such were possible, would adhere to one another perfectly, since their contact would be perfect, and it might then as properly be said that the adjoining particles were held together by cohesion as by adhesion.

WORK AND POWER.

The terms force, work and power are of frequent occurrence in mechanics, and are oftentimes misused. As a definition of force has just been given, it will be advantageous to now take up the subjects of work and power, so that the meanings of the three may be compared and thus firmly impressed upon the memory.

WORK.

Work is said to be performed when a force produces motion in opposition to a resistance. Force has one element only, namely, the push or pull exerted. *Work* is the result of *two* elements, force and motion. When no motion results from the action of a force, no work is done. A jack-screw supporting a weight does no work, except when the screw is turned so as to raise the weight. Likewise, no mechanical work results when a man pushes against a heavy body which he is unable to move, however much it may seem like work to him in the common acceptance of the term. Should he push with equal force against a smaller body, however, and move it, work would be performed.

MEASUREMENT OF WORK.

(*a*) In order to calculate the work done, the magnitude of the force applied is measured in pounds and the distance moved in feet. The product of these quantities, obtained by multiplying them together, is the work in *foot pounds*. Or, briefly stated,

Work = *force* × *distance*.—(1)

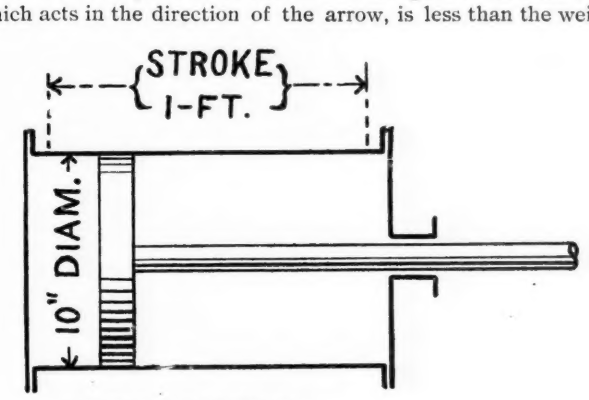
The foot-pound is called the *unit of work*, and may be defined as the work done by a force of one pound acting through a distance of one foot.

(*b*) In the estimation of work it is sometimes more convenient to multiply the resistance overcome by the distance, than to multiply the force applied by the distance, in which case

Work = *resistance* × *distance*.—(2)

It is clear that the resistance and the force applied must always be equal, so that it makes no numerical difference which method is used. For example, if a man raises a weight of 10 pounds through a certain height, he performs work. The resistance of the weight is equal to 10 pounds, and the force that he exerts is just sufficient to raise it, or equal to 10 pounds, also.

(*c*) The simplest example of work is that just cited, of a weight raised against the force of gravity. When solving such examples, care must be taken always to multiply the weight by the *vertical* height through which it moves. Thus, in Fig. 1, suppose the ball B to be rolled from the bottom to the top of the inclined plane. If W represent the weight of the ball and h the height that it is raised, the work done upon the ball would be $W \times h$. It is true that the ball has moved through the distance l, but the force required to roll the ball through this distance, and which acts in the direction of the arrow, is less than the weight



AREA PISTON =
$10^2 \times .7854 = 78.54$ SQ. IN.

FIG. 2.

W, and hence, if W were multiplied by l, the result would be too great. If it were known, however, what force, acting in the direction of the arrow, was required to roll the ball, then this force, multiplied by l, would give the work.

Example 1.—If an elevator car weighing 1,500 pounds be raised a distance of 60 feet to the top of a building, the work done $= 1{,}500 \times 60 = 90{,}000$ foot-pounds. Again, should the car be loaded, so that it weighed with the load 7,500 pounds, 90,000 foot-pounds of work would be done when the car had traveled only 12 feet, since $7{,}500 \times 12 = 90{,}000$. Hence, it will be seen that as much work can be accomplished by a small force acting through a great distance as by a large force acting through a less distance.

Example 2.—It is found that the effective pull exerted by a driving belt passing around a pulley is 200 pounds. If the pulley is 20 inches in diameter, how many foot-pounds of work are performed at each turn of the pulley?

Force = 200 pounds.

Distance in feet belt moves in one turn = circumference of pulley in feet

$$= \frac{20 \times 3.1416}{12} = 5.2361.$$

Work done $= 200 \times 5.236 = 1047.2$ foot-pounds.

The next example illustrates the case of work by a *variable force. When the force or resistance is variable, multiply the average force or resistance by the given distance.*

Example 3.—The diameter of the piston of a steam engine is 10 inches and the length of the stroke 1 foot. If the *mean* steam pressure is 30 pounds per square inch of piston area, how many foot-pounds of work will be performed during 100 revolutions?

The stroke of an engine is the distance traveled by the piston one way; there are two strokes in one revolution, the steam acting first on one side of the piston and then on the other. See fig. 2.

Average force $= 10^2 \times .7854 \times 30 = 2356.2$ pounds.

Distance $= 1 \times 2 \times 100 = 200$ feet.

Work $= 2356.2 \times 200 = 471,240$ foot-pounds.

In the steam engine the steam pressure varies in a very irregular manner, and the mean or average pressure must be obtained by the aid of an indicator diagram. In examples where the force or resistance varies *uniformly*, however, *the average can be found by adding the values at the beginning and end of the motion and dividing by 2.*

Example 4.—A wire rope 300 feet long and weighing 2 pounds per foot hangs by one end from the drum of a hoisting engine and supports a load of 4 tons at the other end. How much work would be expended in winding 200 feet of the rope?

Consider the load and rope separately.

Work done in raising load $= 2,000 \times 4 \times 200 = 1,600,000$ foot-pounds.

At the start, the resistance offered by the rope $= 300 \times 2 = 600$

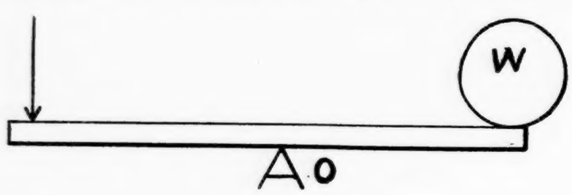


FIG. 3.

pounds. After winding, the resistance $= 100 \times 2 = 200$ pounds.

$$\text{Average resistance} = \frac{600 + 200}{2} = 400 \text{ pounds.}$$

Work $= 400 \times 200 = 80,000$ foot-pounds.

Total work $= 1,600,000 + 80,000 = 1,680,000$ foot-pounds.

POWER.

From what has been said upon work, it is plain that a force, however small, can perform any required amount of work, provided time enough be allowed. A toy engine, for example, might do 1,000,000 foot-pounds of work in a few hours, while an engine of moderate proportions would accomplish as much during a few strokes of the piston. Foot-pounds of work, merely, with time left out of account, would form no basis by which the capacities of the two engines could be compared. Hence, to compare the work done, either by or upon some agent, the time required must be considered.

The term *power* is employed to indicate the quantity of work done in a given time. "One million foot-pounds" is an expression indicating work; 1,000,000 foot-pounds of work performed in a day, an hour or a minute indicates power. Work has the two elements, force and the distance through which the force acts; power has three elements: force, distance and time.

The unit of power adopted for engineering work is the *horse power* (abbreviated H. P.). One horse-power is equal to 33,000 foot-pounds per minute, or it may be said to equal 33,000 pounds raised one foot high in a minute*. Hence, to find the horse-power when work is done, *divide the number of foot-pounds of work done in one minute by 33,000.*

Lest it lead to confusion when met with, it should here be stated that the term power is frequently used by writers on mechanics in the sense of force. In the so-called "mechanical powers," such as the lever, wheel and axle, wedge, screw, etc., it is quite usual to speak of the applied force as the power. Thus, the bar or lever shown in Fig. 3 is pivoted at O and at one end bears the weight W. At the other end a force, such as the pressure of the hand, acts downward in the direction of the arrow, and thus supports or raises the weight W. This pressure, which is the applied force, is what is called the power. Such use of the word, when force is what is meant, is ambiguous and can easily be avoided.

Example 5.—Neglecting losses, how many H. P. would be required to pump 2,500 gallons of water from a depth of 200 feet in $2\frac{1}{2}$ minutes? One gallon of water weighs 8.355 pounds.

Resistance $= 8.355 \times 2,500 = 20,887.5$ pounds.

Distance = 200 feet.

Work done in $2\frac{1}{2}$ minutes $= 20,887.5 \times 200 = 4,177,500$ foot-lbs.

Work done in 1 minute =

$$\frac{4,177,500}{2\frac{1}{2}} = 1,671,000 \text{ foot-pounds.}$$

$$\text{H. P.} = \frac{1,671,000}{33,000} = 50.64, \text{ nearly.}$$

Example 6.—How long would it take an engine of 30 H. P. to accomplish the same amount of work?

Work to be done $= 4,177,500$ foot-pounds.

Work that engine can do in 1 minute $= 30 \times 33,000 = 990,000$ foot-pounds.

$$\text{Time required} = \frac{4,177,500}{990,000} = 4.22 \text{ minutes, nearly.}$$

Example 7.—If the engine of Ex. 3 runs at 100 revolutions per minute, what is its H. P.?

The work done by the engine during 100 revolutions was found to be 471,240 foot-pounds.

$$\text{Hence, H. P.} = \frac{471,240}{33,000} = 14.28.$$

Reviewing examples 3 and 7, it will be seen that in finding the horse-power of the engine we multiplied together the area of the piston in square inches, the average pressure (called the mean effective pressure), the length of the stroke in feet and twice the number of revolutions per minute. We then divided the product of the quantities by 33,000. These operations may be indicated as follows:

Let A = area of piston in square inches.
" P = mean effective pressure in pounds per square inch.
" L = length of stroke in feet.
" N = number of revolutions per minute.

Then,

$$\text{H. P.} = \frac{2\,P\,L\,A\,N}{33,000} \qquad (3)$$

which is the formula for the horse-power of an engine.

EXERCISES.

1. (*a*) How many units of work are done in pumping 10,000 cubic feet of water from a mine 500 feet deep? (*b*) If the work were done in 30 minutes, what would be the H. P. required? A cubic foot of water weighs 62.5 pounds.

2. How would you compute the mechanical work done by a man who walks up a spiral staircase?

3. If the resistance of a railroad train at 50 miles an hour is 20 pounds per ton, (*a*) how much work would be done in a minute by a locomotive hauling a train weighing 100 tons at this speed? (*b*) What effective H. P. would it develop? There are 5,280 feet in a mile.

4. A chain 50 feet long and weighing 15 pounds per foot lies coiled on the ground. Find the number of foot-pounds of work required to just raise it from the ground by one end.

5. Forty thousand cubic feet of water pass over a dam 16 feet high in an hour. What would be the H. P. of a water-wheel which would utilize 60 per cent. of this power?

6. Find the H. P. of a steam engine from the following data: Diameter of cylinder, 14 inches; length of stroke, 2 feet; number of revolutions per minute, 90; mean effective pressure, 40 pounds per square inch.

7. In a gas engine the pressure acts on one side of the piston only, and at every *second* revolution; that is, it skips every other revolution. Given, mean pressure for a gas engine, 80 pounds per square inch; area of piston, 85 square inches; length of stroke, 18 inches; revolutions per minute, 154. What is its H. P.?

* The horse-power unit was introduced by James Watt, the great improver of the steam engine, for the purpose of reckoning the power developed by his engines. He had ascertained by experiment that an average cart-horse could develop 22,000 foot-pounds of work per minute, and being anxious to give good value to the purchasers of his engines he added 50 per cent. to this amount, thus obtaining (22,000+11,000) the 33,000 foot-pounds per minute unit by which the power of steam and other engines has ever since been estimated.—JAMIESON'S APPLIED MECHANICS.

MACHINE SHOP ARITHMETIC.

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PRACTICAL QUESTIONS CONNECTED WITH THIS SUBJECT WILL RECEIVE PROMPT ATTENTION.

SQUARE ROOT.

W. L. CHENEY.

It may easily be imagined that once upon a time some fellow with a great head (for that time), while investigating mathematical problems, possibly with nothing better than a handful of pebbles for instruments, made the great (for the time) discovery that while twelve times twelve pebbles was one hundred and forty-four pebbles, that one-half of twelve times one-half twelve pebbles was not one half of one hundred and forty-four pebbles, but was *one-quarter* of one hundred and forty-four pebbles. It may also be easily imagined that this old established mathematical investigator arrived at this conclusion by putting his pebbles in twelve rows of twelve each, and six rows of six each, forming two *squares*, one of which was evidently four times the size of the other by eye measurement, as well as containing four times as many pebbles by actual count.

After he had made a few of these *squares* it probably occurred to him that when he went to the post office to get one hundred postage stamps, it wasn't necessary for him to count the whole hundred, but simply to count and see if he had ten on each *side* of his *square;* and finally, he probably fell into the unconscious habit of performing simple mental operations in extracting *square root*, by asking himself perhaps something as follows: Now, I want to make a box to hold 144 eggs, each egg to be in a compartment by itself, the box to be a *square* box; how many compartments on each *side* of the *square* box must I have to hold the 144 eggs? Why, 12, of course, any fool knows that.

About this time, or some other time, (it doesn't make much difference what the *time* was, it not being a yacht race) some other fellow (or perhaps this same fellow, also with a great head, for those times or any other times) made the discovery that in a right-angled triangle the square of the hypothenuse is equal to the sum of the squares of the other two sides of the triangle (I *think* this fellow's name was Euclid, but that really doesn't matter either, because the *truth* that he discovered remains the same, whatever his name was).

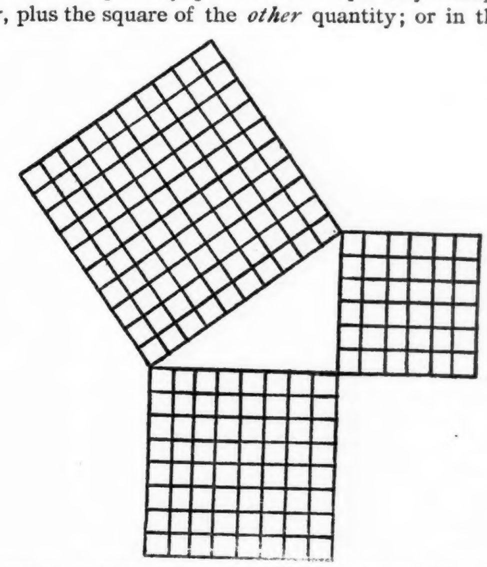
That is, if one *square* of 36 pebbles is placed in such a position regarding another *square* of 64 pebbles, that two of their *sides* form a right-angled triangle, it will be seen that one side of another *square* of 100 pebbles will exactly form the hypothenuse or third side of the triangle, the square of 100 pebbles being equal to the sum of both the other squares; that is 36 and 64 make a total of 100 (see the figure, each small square representing a pebble).

Now, it *might* be that what is true of a right-angled triangle of the above dimensions, would not be true of any other triangle. If we take two squares, for instance, of 25 and 16, the sum of which are 41, we cannot come to any conclusion whatever on this particular question, because we cannot arrange our 41 pebbles in the form of a square, *and this is exactly where Euclid got in his fine work*, in consequence of which I say he had a great head.

He proved to a dead certainty that this would hold true, no matter what quantitities or numbers entered into the problem, and to deal with this and other things to follow it is now necessary to begin to consider the idea of *unity;* that is *one;* one pebble, one *bushel* of pebbles, one *barrel* of pebbles, one *half* ton of pebbles, one *half* of a pebble. That twice *one* are *two;* twice one *pebble* are *two* pebbles; twice one bushel, *two* bushels; twice one barrel, *two* barrels; twice one half ton, *two* half tons; twice one half of a pebble, *two* halves of a pebble, whether actually in two pieces or in the form of one whole pebble. Every thing in the world taken together make *one* world; the smallest pebble in the world may be considered as being composed of two halves, four quarters, or a thousand thousandths, or in any other way we choose to divide it, or may be considered as *one half* of *two* pebbles.

The truth that in a right-angled triangle, the square of the hypothenuse is equal to the sum of the squares of the other two sides being accepted, it of course follows that if we can find some way to calculate just what the side of a square of these 41 pebbles would be, supposing that they were ground to powder and put in a square, or when the number is too large to make an easy mental calculation (as when you count the sheet of 100 stamps), we can solve many problems that come up in machine shops, such for instance as the exact angle to set a grinding machine to grind a cutter for screw threads, supposing that the cutter is to be held in a holder made to hold the cutter with a standard *clearance*. In other words, many problems coming up in fine machine work, necessitating a knowledge of how to *extract square root*.

Some of these fellows with great heads found while playing with their pebbles that the law of squares was a universal law; that his square of 12 pebbles on a side was always 144 pebbles, whether he *considered* it as 12 on a side, or 11 and 1 on a side, or 10 and 2 on a side, or 9 and 3 on a side, and so on through the scale, and they also found that when they did consider their sides of squares as being made up of two quantities, that a universal law held good that the square was always made up as follows: The square of one quantity, plus twice one quantity multiplied by the *other*, plus the square of the *other* quantity; or in the algebraic language, representing one quantity (no matter which or what size) by a, and the other by b, then the square of a plus b is equal to a square, plus two $a\,b$, plus b square, or in algebraic signs $(a+b)^2=a^2+2\,a\,b+b^2$.



Let us try some and see how it comes out, considering 12 as 11 and 1 (or 11 plus 1):

11 squared	121
Twice 11 times 1	22
1 squared	1
Total	144

Considering 12 as 10 plus 2:

10 squared	100
Twice 10 times 2	40
2 squared	4
Total	144

Considering 12 as 9 plus 3:

9 squared	81
Twice 9 times 3	54
3 squared	9
Total	144

Having found out how the square is made up, it was easy enough to pull it to pieces again, or in other words to *extract the square root*, by simply reversing the process by which it was considered the square was made up.

Before proceeding further, we must understand one simple law of multiplication and division—multiplication being simply *supplying* a certain *quantity* a certain number of *times*, same as our ancient friend did when he *supplied* 12 *pebbles* 12 *times* to make his 144 pebbles; and division being simply the *taking away* a certain quantity a certain number of times.

Supplying 12 pebbles 12 times is multiplying 12 by 12, and dividing 144 by 12 is taking 12 lots of 12 pebbles from 144 pebbles, in which case we have no pebbles remaining in the original lot of 144. It follows then, that when a certain quantity is made up by multiplying two *other quantities* together if the certain quantity is *divided* by either of the *other two quantities* that went to make it up, that the result must be *the other one of the two quantities;* that is, if we multiply 4 by 5, making 20, if we divide 20 by 5 the result *must be* 4, or if we divide 20 by 4 the result *must be* 5.

We can now pick the square 144 to pieces as follows, assuming it to be made up of sides of 11 and 1:

Take away from 144 the square of 11:

	144
The square of 11	121
	23 remaining

Take from the 23 remaining the square of 1:

	23
The square of 1	1
	22 remaining

Take away from 22 twice 11 times 1:

	22
Twice 11 times 1	22
	—— nothing
	00 remaining

Assuming the square 144 to be made up of sides of 10 and 2:

Take from 144 the square of 10:

	144
The square of 10	100
	44 remaining

Take from the 44 remaining the square of 2:

	44
The square of 2	4
	40 remaining

Take from 40 twice 10 times 2:

	40
Twice 10 times 2	40
	—— nothing
	00 remaining

It will be found that *any* square can be made up and pulled down in the same way; of course it is simple enough when we know how it is made up, to pull it down again.

Now, as it is an accepted custom (*not a mathematical principle*) that numbers increase in value by ten for each place to the left as they are written, let us consider that 144 is the square of something composed of *units* and *tens* (we already *know* it to be composed of *one ten* and *two units*, but this knowledge must not enter into the operation which we are about to perform), and as the square of units *cannot* be greater than tens (9 largest unit, 81 its square), and as the square of tens cannot be greater than thousands (99 largest ten, 9801 its square), we will separate the number 144 into tens and thousands (these being the squares of units and tens) by following the custom of "pointing off" from the units number into "periods of two figures each."

We have now divided our lot of 144 pebbles, if you please, into two lots (or "periods"), one lot consisting of 100 pebbles and the other lot consisting of 44 pebbles (or 4 tens pebbles and 4 units pebbles), simply because it is *customary*, as explained above, to write numbers in units, tens, hundreds, etc., etc.

The left-hand "period" of 1, then, represents a *unity of hundreds*, that is *one* hundred—*one* hundred pebbles. Let us take away from this period of 1 (no matter now one *what*) *the largest square there is in it*, which is evidently 1, *we have pulled out the square of the tens of which the square number 144 was made up, haven't we?* That is, we have extracted the square root of all the tens making up the thousands "period" and find it to be *one ten;* we will therefore put down this one ten thus: .1, ***not forgetting that it stands in the* TENS PLACE.**

Now let us go back to the principle of multiplication and division as touched on above:

Having found what the square root of the tens is, and knowing the way that the square is made up, we can now deal with the remaining 44.

Having considered the *root* to have been made up of *units* and *tens*, let us call the tens a and the units b, and look at the algebraic formula again: $(a+b)^2=a^2+2\,a\,b+b^2$.

We have already dealt with the a^2 and set down its root a, in the form of a figure 1 (in the tens place), and now considering the remaining 44 as being also units and tens (4 units and 4 tens), let us see what we can do towards picking out the $2\,a\,b$ of the algebraic formula. We know what the a is; it is 1, and if we divide the tens of the remaining 44 by $2\,a$ (which in this case is 2), it will give us a *hint* of what b is; thus we get a hint that b is 2; we therefore consider that it is 2, and see how the experiment comes out. Having already taken away the square of the tens, which is the a^2 of the formula, *if* b is 2, and we multiply it by itself, it will give us 4 units and fulfill the b^2 of the formula, and if we multiply it by $2\,a$, which is 20, it will give us twice the tens multiplied by 2 or the $2\,a\,b$ of the formula, this being in this case 40, or 4 *in the tens place*.

That is, the $2\,a\,b+b^2$ of the formula is made up of $2\,a$ multiplied by b, and b multiplied by b, which is of course b^2, and, referring back to the *principle* of multiplication and division explained above, dividing the $2\,a\,b$ of the formula by the $2\,a$, which we already know, *must* give us the b, *if* the number 144 is a perfect square, which we know it to be in this case; hence the "double the root already found for a trial divisor" of the conventional rule for square root.

Practically if no number can be found by trial that will fulfill the conditions of b, the largest that will go must be taken, and the remainder considered as a decimal fraction, and operation to to be repeated until the root is extracted as far as wanted. The correctness of this is manifest when we consider that one ten is equal to ten units, and one unit is equal to ten tenths, and one tenth to ten hundredths, etc., each place to the left increasing the value of a figure, the decimal point having no value, but simply shows where *unity begins*.

A comparison of these principles and explanations, step by step with the operation of extracting square root as done by the conventional rule, cannot, it seems to me, fail to make the subject clear, and when once the subject *is* clear, there is less liability of mistakes when doing a problem by the rule, to say nothing of the advantage of being able to get along without the rule if the book is mislaid or the memory weak. When the principle of extracting roots is once mastered it is a fascinating amusement as well as valuable practice, to extract 4th, 5th, 6th, etc., roots for which no rules are usually to be found.

* * *

PATTERN MAKING.

A very good "kink" in pattern-making may be found in the shops of the Ferracute Machine Co. In order to produce cheaper patterns, some of which are rather temporary in their character, and all of which in these days of improvement are subject to alterations, they find that it pays best to put them together in as cheap a way as possible, without any regard to the elegant joiner-work of the old-fashioned pattern-makers, providing they give them strength enough to serve their purpose and get them the right size and shape. In general they pay a good deal more attention to the artistic form, in the way of nicely rounded fillets and corners, and harmonious curves, together with as much absence as possible of external rib-work, than they do to a beautiful job of fitting and joining. To accomplish this they use mill-dressed lumber, planed to accurate thickness as much as possible, and cut their work to shape wherever they can with square band-saws and "Fox" trimming machines. They avoid expensively carved wooden fillets, putting in ready-made lead and leather fillets, or oftener, extemporized fillets of putty mixed with litharge and shellac, being careful to shellac the surfaces before applying them; sometimes, with large fillets, putting in a few rows of nails by way of anchorage.

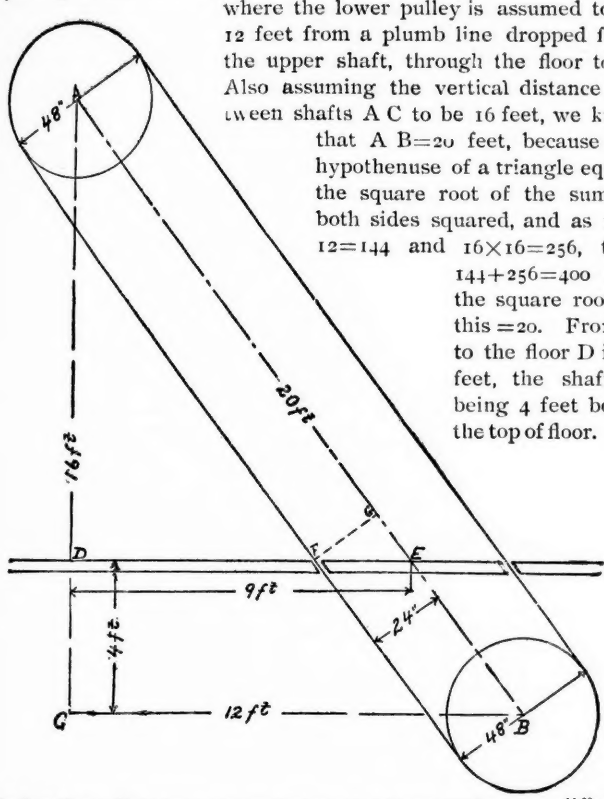
To rub the putty down to proper shape and give sufficient hardness, they use spherical-ended brass formers, which they keep on hand, made to all the different radii required. They find that polished brass works better than any other metal that they have tried, as it does not stick to the somewhat juicy mixture of putty and shellac varnish, as does iron for instance.

HOW AND WHY.

A COLUMN INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST. GIVE ALL DETAILS AND YOUR NAME AND ADDRESS, WHICH WILL NOT BE PUBLISHED UNLESS DESIRED.

5. A. C. L. asks: 1. What should be the ratios of the cylinders of a triple-expansion engine? *A.* Practice varies considerably in this respect, and sometimes varies widely. At 150 pounds pressure, which is a very common pressure for such engines, the ratios may be 1—2.50—6.85. If the pressure is 160 pounds, then the ratios may be 1—2.65—7.21. At 130 pounds pressure, which is about the lowest permissible with this type of engine, the cylinder ratios may be 1—2.15—4.87. But all three are subject to modification in construction, the whole matter being a complicated one, the problem being to keep the fall in temperature as mean as practicable, alike in all cylinders.

6. T. P. asks: 1. In belting pulleys together, one above the other below the floor, also at an angle, how shall I cut a hole to pass belt? *A.* While this is rather indefinite, we interpret it to mean passing a belt through the floor at angle to it as in the figure,



where the lower pulley is assumed to be 12 feet from a plumb line dropped from the upper shaft, through the floor to C. Also assuming the vertical distance between shafts A C to be 16 feet, we know that A B=20 feet, because the hypothenuse of a triangle equals the square root of the sum of both sides squared, and as 12×12=144 and 16×16=256, then 144+256=400 and the square root of this =20. From A to the floor D is 12 feet, the shaft B being 4 feet below the top of floor. By laying these distances out on paper, on a large scale, these different dimensions can be measured, the proper places for belt found, but they can also be figured out as follows: As the angle in each are equal, that is, the angle A B C and A E D are equal angles, if the base C B is 12 feet when the side is 16 feet, it follows that D E must be as 16 : 12 :: 12 : 9, or 9 feet, and E, the center line between shafts will be 9 feet from the plumb line and D. Mark this on the floor. Now we have another case of similar angles, and as the pulleys are 48 inches in diameter the distance F G must be 24 inches. This side of the triangle corresponds with A C of the large triangle, and we again use proportion and say as 16 : 20 :: 24 : 30, showing that E F equals 30 inches, and by laying off 30 inches each way from E we have the position of the inside of the belts, providing there was no sag. For this length of belt two inches will probably allow for sag and enough should be added to width of hole through floor to allow for a certain amount of "flapping" while running. Belts of this kind should be thoroughly boxed in, to protect any person who happens to be near from being injured by it. If the inquirer means that the shafts are directly under each other but that the shafts are not parallel, so as to cause a twist in the belt, these directions do not apply, but it can be worked out on paper, or by dropping plumb lines from the center and from each edge of the upper pulley to the floor and marking these points. Then project similar points from the lower one to the ceiling. Bore a small hole at the central points, which will probably coincide. Divide the difference between the extreme points in proportion to the distance the floor is from each pulley, *i. e.*, if the variation between points is two inches, and the center of pulley under the floor is 4 feet from floor while the upper pulley is 12 feet above the floor. The ratio is as 4 to 16 (total distance) or 1 to 4, and the point to select is within $\frac{1}{4}$ of the variation, nearest the point of lower pulley. The variation being two inches, this point lies $\frac{1}{2}$ inch from mark of lower pulley, and as the other side is similar there will be little trouble in laying the hole out correctly, the allowance for swaying of belt also gives considerable margin. 2. How is the shaft of an engine set or "squared" with the cylinder, or one shaft squared with another? *A.* Squaring an engine shaft with the cylinder is done by running a line through the center of the cylinder and with a try square test shaft till it is square with the line. You will find further information in the article on this subject by "Spike" in another column. Squaring one shaft with another is easily done. Suppose both to be level, it is only necessary to adjust them until they are the same distance apart at each end, or, in other words, are parallel. 3. What is the best kind of floor for machine shops? *A.* We prefer asphalt laid on a good foundation where possible, but as this is practically confined to ground floors, other kinds must be used for the upper stories. For this there is probably nothing better than good hard pine over substantial planking, as when badly worn it can be taken up and a new one laid. 4. This question is too indefinite to be answered. We have no means of knowing the power required, although if one horse can operate it continuously, it is not over 22,000 foot pounds per minute, with probably nearly 50 per cent. lost in friction. Give all details and we may be able to help you.

* * *

FOR THE NOTE BOOK.

IN THIS COLUMN WE PUBLISH PRACTICAL RULES AND DATA THAT WILL BE FOUND USEFUL TO SHOPMEN GENERALLY; AND WE SHALL BE PLEASED TO CREDIT ANY CONTRIBUTION THERETO.

QUESTIONS CONCERNING ANY OF THESE NOTES WILL RECEIVE CAREFUL ATTENTION.

THE *Indian Engineer* says the following is an excellent recipe for covering pulleys with leather on paper: Spread over the metal a thin solution of hot glue. Soak or sponge the leather well with a warm solution of gallnuts before placing it on the metal. Press down firmly and let dry. Cemented in this way, leather will tear before it can be separated from the metal. Split leather is fully as good as, if not better than, any other kind. Paper may also be used to cover a pulley and fastened in the same manner.

BALL BEARINGS.

There is often considerable discussion regarding the proportion and distribution of balls for machinery bearings. Our correspondent, Mr. W. H. Booth, who has had considerable experience in this line, gives 500 pounds as an allowable pressure for a ball $\frac{1}{4}$ inch in diameter, and gives the formula of $31\,d^2$ allowable pressure, when d is the diameter in *sixteenths* of an inch. With a ball $\frac{3}{8}$ inch in diameter we have $\frac{3}{8} = \frac{6}{16}$. Then $d = 6$ and 6 squared $= 6 \times 6 = 36$. Multiplied by 31 it gives, $36 \times 31 = 1{,}116$ pounds as allowable pressure on bearing.

BEARING METALS.

The old alloy of 7 parts copper to 1 of tin has, according to Dr. Dudley, chemist of the Pennsylvania Railroad, given way to a much better metal, which is now their standard for car and similar bearings. The formula is: Copper, 105 pounds; phosphor-bronze, 60 pounds; tin, $9\frac{3}{4}$ pounds; lead, $25\frac{1}{4}$ pounds. With ordinary care in the foundry, keeping the metal well covered with charcoal during the melting, there is no difficulty is casting good bearings with this mixture. The copper and phosphor-bronze can best be put in the pot before putting in the furnace; the tin and lead should be added after the pot is taken from the fire.

For shafting running from 390 to 400 revolutions per minute, an alloy of 8 parts zinc and 2 parts block tin is recommended by Mr. C. R. Tomkins. For high speed work he favors a mixture of 8 pounds of tin to 2 pounds of antimony, but cautions against overheating in melting; "scorching a dry pine stick" being the guide given.

DIAMETERS AND REVOLUTIONS OF PULLEYS.

To find the diameter of a pulley and the number of revolutions per minute it should make to produce a given desired belt speed in feet per minute.

Multiply the belt speed by 3.82 and divide the product by any

diameter in inches, when the quotient will be the number of revolutions per minute it should make.

Example.—What diameter of pulley and number of revolutions will produce a belt speed of 600 feet per minute?

600 × 3 82 = 2,292, and

$$\frac{2{,}292}{8 \text{ in. diam.}} = 286\tfrac{1}{2} \text{ revolutions, also}$$

$$\frac{2{,}292}{12 \text{ in. diam.}} = 191 \text{ revolutions.}$$

In like manner dividing the product of belt speed and 3.82 by any number of revolutions will give the corresponding diameter of the pulley. WM. COX.

KEEPING TOOLS FROM RUSTING.

The *Canadian Engineer* gives the following recipes for a preparation for keeping tools from rusting: Dissolve ½ ounce of camphor in 1 pound of melted lard. take off the scum, and mix in as much black lead (graphite) as will give it an iron color. Smear the tools with this mixture, and after 24 hours rub clean with a soft linen cloth. Another coating is made by mixing slowly 6 ounces of lard to 1 ounce of resin and stirring till cool. When semi-fluid it is ready for use.

* * *

WHAT MECHANICS THINK.

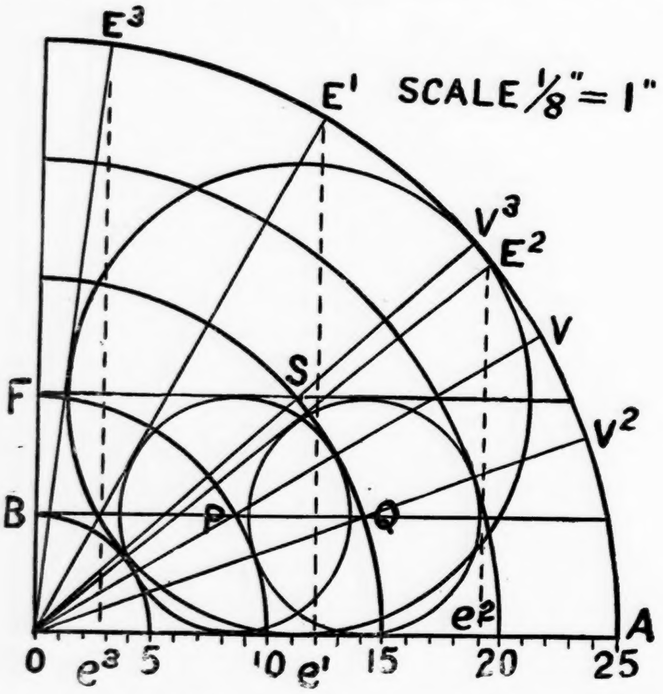
THIS COLUMN IS OPEN FOR THE EXPRESSION OF PRACTICAL IDEAS OF INTEREST, TECHNICAL OR OTHERWISE. WRITE ON ONE SIDE OF THE PAPER ONLY, AND BOIL IT DOWN.

WHEN SKETCHES ARE NECESSARY TO ILLUSTRATE THE IDEA, SEND THEM ALONG—NO MATTER HOW ROUGH THEY MAY BE, WE WILL SEE THAT THEY ARE PROPERLY REPRODUCED.

ABOUT SLIDE VALVES.

On constructing diagrams as directed in Mr. Robert Grimshaw's article on slide valve study in your last issue, I find great trouble, in fact impossibility, in applying same according to directions.

How can he draw a circle 1¼ inches in diameter with center 5 inches above base line, which will just touch the base line? This



is one question which crops up before me and it is by no means the only one. WM. L. MAHON, M. E.

Detroit, Mich.

ANSWER.—Careful inspection of both text and illustration show that they agreed with each other and that both were correct; although your photo-reduction of my rough diagram to 3 inches laterally, instead of 3⅛ inches, to represent a length of 25 inches, made it rather less easy to work with.

Where in the second column of page 9, I take the case of an engine having a valve-travel of 5 inches, steam lap 1¼ inches, and piston stroke 20 inches (= effective crank length 10 inches) it is evident that I can use the same quadrant to represent at once (on different scales) the paths of the main crank-pin and of that crank-pin which would give the valve 5 inches travel; both cranks being supposed to drive through "Scotch yokes" so as to obviate irregularities due to angularity of connecting-rods and eccentric-rods. This being the case, if I choose the 10-inch quadrant as representing, on a scale of 1 : 1, the main crank-pin path, the scale for the "valve-circle" and lap-circle will be 2 : 1; the circle representing a 1¼-inch lap will be 2½ inch radius instead of 1¼ inch; and if centered where horizontal line 5 cuts quadrant 10, it will just touch the base-line O A, which represents the line of dead centers. The tangent O E^1 cutting all the quadrants, indicates at what point in the crankpin path of any stroke of engine cut-off would take place with this proportion between steam-lap and valve-travel; being about 61° from the center line.

Verticals dropped from where this tangent O E^1 cuts the various quadrants indicate in inches at what point in the stroke of engines having from 2 inches to 25 inches crank-length (= 4 inches to 50 inches stroke) cut-off would take place with this proportion between steam lap and valve travel; thus, about 5 inches past mid-stroke in an engine of 20 inches stroke; at about 7¾ inches past mid-stroke in one of 32 inches; at about 12⅛ inches past mid-stroke in one of 50 inches, and so on.

To show the adaptability of this system of using what is known as the Bilgram slide-valve diagram (which I regard as much better than Zeuner's) I sketch in outline the same equivalent to represent the following cases:

No.	Piston Stroke. Inches.	Valve Travel. Inches.	Steam Lap. Inches.
1	20	5	1¼
2	30	7½	1¼
3	30	7½	2½
4	40	5	1¼
5	60	7½	1¼
6	60	7½	2½

The line O A is marked off in the diagram (which I have drawn on a scale of 1 : 8) as representing an effective crank-radius of 25 inches; and I have drawn crank-paths of 5, 10, 15 and 20 inches radius respectively.

(The following paragraph refer by letters to this new diagram, although they apply as regards numbers, positions and dimensions to the diagram in your August issue.)

For case 1 there is drawn a circle centered at P, having an actual diameter of 1¼ inches and on a quadrant representing a circle of 2½ inches actual diameter. The distance O B is actually ⅝ inch and represents the lap of 1¼ inches to half size, just as the circle of 2½ inches actual diameter represents the path of the valve-driving crank-pin, half size.

Then the tangent O E^1 represents the crank position at point of cut-off, for 20 inches (or any other) stroke, O A being the line of dead centers; horizontal in this case. The perpendicular E^1 e^1 cuts O A at a point situated about $\frac{12}{25}$ or $\frac{48}{100}$ of the second half stroke of the piston, or $\frac{74}{100}$ of the whole stroke—which would be 14.8 inches of a 20-inch stroke.

The line O V drawn through P from O, or any part of such line, makes with O A the angle representing the necessary angular advance of the eccentric (where no rocker-arm is used) to effect cut-off at that point, without steam lead, with that proportion between valve-lap and valve travel.

For case 2, center the lap circle of ⅝ inch actual radius at Q, which is on the arc of 3¾ inches actual diameter; and make the tangent O E^2. This represents crank position for 1¼ inch steam lap and 7½ inches valve travel (or for any similar proportion between steam-lap and valve travel) for 30 inches (or any other) iston stroke. The perpendicular E^2 e_2 cuts O A at about the 19 mark, showing cut-off to be at $\frac{19}{25}$ the half stroke, or 88 per cent. of the whole stroke; *i. e.*, at 25.8 inches for 30 inches stroke. The radius O V^2 passing through Q makes with O A the necessary "angle of advance" for the crank.

In case 3, draw a line 1¼ inch actual distance above O A, and at S where it cuts the arc of 1⅞ inch actual radius or 3¾ inches actual diameter, make a lap-circle 2½ inches actual diameter. The tangent O E^3 represents the crank-position for 2½ inches steam lap and 7½ inches valve-travel (or for any similar proportion of these elements) for 30 inches (or any other) piston-stroke; the angle V^3 O A the angle of advance of the eccentric for 2½ inches lap and 7½ inches valve-travel, no matter what the stroke. The perpendicular E^3 e_3 strikes O A about the 2½ point, showing that cut-off would be at 2½-25 or $\frac{1}{10}$ of the second half of the stroke, or $\frac{11}{20}$ of the whole stroke. For stroke 30 inches, this would be 16½ inches (and incidentally I may say that such a cut-off, with a plain slide-valve, would cramp the exhaust so as to make the engine inoperative).

For case 4, with 1¼-inch lap, 5 inches travel and 40 inches

stroke, the cut-off would take place at the same crank angle and proportion of piston stroke as for case 1; but in inches of stroke it would be at 29.6″. The angular advance would be the same number of degrees as for case 1 (about 30° of arc).

In case 5, we have the same crank angle at point of cut-off, and same angular advance of eccentric (about 20°) as in case 2; the cut-off is at the same proportion of the stroke, but in inches it would be 52.8″.

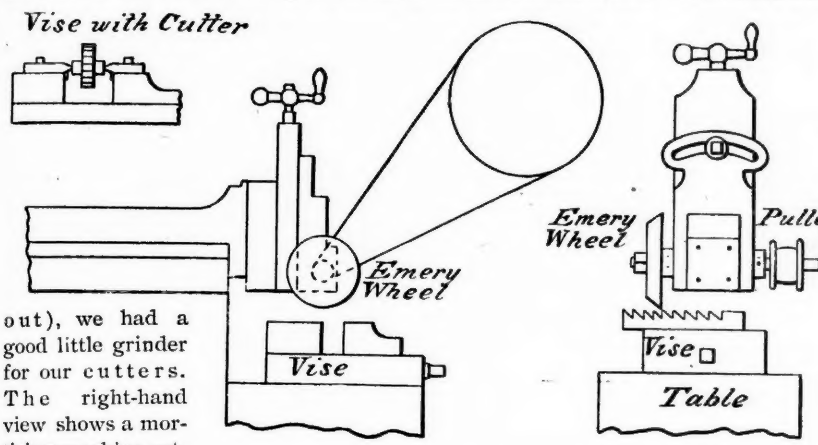
In case 6, the crank-angle at cut-off would be the same as in case 3; the angular advance of eccentric the same (about 42°) and the proportionate part of stroke at cut-off the same; in inches, about 33 (cramped exhaust).

In all the foregoing, there is supposed to be no irregularity from angularity of connecting-rod or of eccentric rod; no rocker-arm, and no steam-lead. Corrections for these may be made when desired, using the same diagram. ROBERT GRIMSHAW.

5539 Pulaski Avenue, Philadelphia, Pa.

AN IMPROVISED CUTTER GRINDER.

Having some cutters to grind and having no grinder that could do the work well, one of our men rigged a wheel and arbor to the tool-block of a small shaper, and driving the wheel from an overhead drum, as shown in the side view (and a tightener which is not shown, but which took up the slack as the ram moved in and out), we had a good little grinder for our cutters. The right-hand view shows a mortising machine cutter held in the chuck of the shaper while the wheel carried by the ram travels back and forth across the face. The small view at the left is a pair of centers which we fastened to the vice jaws as shown, for holding circular milling cutters on an arbor. We have found this useful for cutters, and have also used it for small surface work, the movement of the wheel making it wear very evenly and doing nice work.



Asheville, N. C. R. K.

CONE PULLEYS AGAIN.

Among the "bundles of old straw," which come up to be "rethreshed" annually, is the one on "How to proportion cone (or step) pulleys," so as to have the belt fit them all, and it appears so often, that I will venture to send you my rule published many years since, in the hope that it may answer the question for some one who has not seen it.

The first thing to be done is to determine the length of the belt, which in all cases is to be the same, and this is most simply ascertained by adding to twice the distance between the center of the shafts, twice the semi-circumference of the even pulleys, of which there are usually a pair in a set of cones, or the full circumference of one of them, which is the same thing. This gives the positive length of the belt.

Now, on a pair of step pulleys, the length of belt between pulleys is not the exact distance from center to center of shafts, but is the hypothenuse of a right angled triangle, of which that distance is the perpendicular, and the difference between the radii is the base. To get this, assume a pair of pulleys, of proper proportions, to give the desired change of speed, but the sum of whose diameters shall be the same as the diameters of the two even pulleys. Square the distance between shafts, add to this the square of the base, or the difference in the radii, and take the square root of the sum. This gives you the belt length between the center *line* of the two pulleys. Double this and subtract it from the length of belt already ascertained. The remainder is the sum of the semi-circumference of the two step pulleys, which divide between them in the ratio first assumed

For instance, suppose a pair of shafts, 6 feet apart, from which you want to drive, at an even speed, and at increased or decreased velocities of 2 to 1, 3 to 1 and 4 to 1 respectively.

If your equal pulleys are 12 inches diameter, the apparent diameters of the others would be 16 to 8=24, 18 to 6=24, and 19.2 to 4.8=24, the sum of the even diameters. Now you will find in practice that your belt will not be long enough for these steps without being stretched too tight, and that a belt which would fit the last step would be too loose on the even pulleys, or the intermediate ones.

In the case assumed, the length of belt would be 6 ftx2+3.1416 =15.1416 feet.

Let us take the 3 to 1 speed for an example, the rule for all the others will be the same.

Distance between pulleys 6 feet, or 72 inches; square=5,184 inches. Difference in radii 6 inches; square of this=36. Total 5,220 inches. $\sqrt{5,220}=72.249$ inches. Multiply this by two gives you 144.498 inches, or 12.0415 feet as the length of belt. Subtract this from 15.1416 leaves 3.1001, as the semi-circumference of the two pulleys, instead of 3.1416. Now take ⅔ of this for the size of the large pulley and ⅓ for the smaller one, gives 2.0667 feet and 1.0333 feet respectively for the semi-circumferences of the two pulleys, or 4.1334 and 2.0667 as their circumference, and their diameters will be 15.788 inches and 7.894 inches instead of 16 and 8.

In the step of 4 to 1 the slope of the belt will be greater, the hypothenuse longer, and the consequent reduction in the pulleys greater.

This is not entirely correct mathematically, for the difference in radii of the pulleys as found, will be slightly less than the one assumed as the base of the triangle, but in ordinary cases it will be so infinitesimal as not to be worth notice, and will be readily taken care of by the elasticity of the belt. If we come to a nicety on the point, it will be so slight as to be practically undiscernible, unless the difference between pulleys is very great and the distance between centers very short.

Charleston, N. H. SAMUEL WEBBER.

THE PERSONAL FACTOR IN STEAM-PLANT MANAGEMENT.

The very interesting article on "Wastes from Boiler Management," in June MACHINERY, by R. C. Carpenter calls attention to a state of things which actual experience proves to exist in the majority of steam plants throughout the country. But in one point I differ with him. Speaking of losses from improper firing, unburned coal in the ashes, etc., he says: "This is a loss which the fireman is largely responsible for." It will be found that the ordinary fireman, like other men in similar positions, will do just as he is required, and if left to his own devices will perform his work in the manner requiring the least constant care and attention on his part.

The average fireman possesses neither the capacity nor the application to attain the standard required for the operation of boilers with maximum efficiency and economy. For that matter, how many engineers, under whose eye the fireman is supposed to perform his labors, possess these requirements? Important steam plants are found in charge of men, safe and reliable to be sure, but men sadly lacking in that knowledge, and in that unremitting care and attentions, required for the operation of their plants under conditions of maximum efficiency and economy.

A steam plant does not at all resemble a watch, which, once placed in order by the expert, will continue to keep perfect time for a long period, provided it be kept wound up. But to attain the highest economy continuously requires the care and adjustments of the expert.

Right here is a subject upon which many owners and managers of steam plants sorely need education. Many of our best and brighest engineers, after having accomplished wonders in the way of improvements and decreased expenses, have run up against the disheartening rock of injustice and indifference displayed by narrow-minded and, in this respect, uneducated managers or owners. That great bugbear of many owners and managers, the salary of their engineer and the wages of their firemen, would soon lose its terrors were they properly educated up to the absolute necessity of having, for the brains of their steam plants, men in charge thoroughly conversant with the processes going on in their furnaces, boilers and engines, and with the best modes of operating the same under the changing condi-

tions imposed by the varying demands of everyday service.

This education accomplished, there will be realized the insignificance of the few dollars difference between the salary of the safe and reliable man and the salary of the man not only safe and reliable, but also capable of satisfying the great modern demands for *efficiency* and *economy*, Then will the engineers be found ready and willing to respond, and instead of sitting down conscience-free as soon as they succeed in making the engine run quietly and yield a passable card, they will be found out in the fire-room also, instructing and supervising their firemen, inspecting their ash-pile, noting the varying readings of the pyrometer in the uptake and trying to lower these readings and diminish their variations; searching for and stopping air-leaks striving to obtain the best possible proportion of grate to heating surface, and the draft intensity best adapted to the existing power demand, examining the interior of their boilers at frequent intervals and using the best means in their power to reduce or prevent scale, keeping posted upon the condition of the back connections, the brick-work, bridge walls and grates; but above all, closely watching the firemen at their work. There is no insurmountable difficulty in getting firemen to perform their work properly. The all-important requisite is the intelligent supervision of a *competent* engineer.

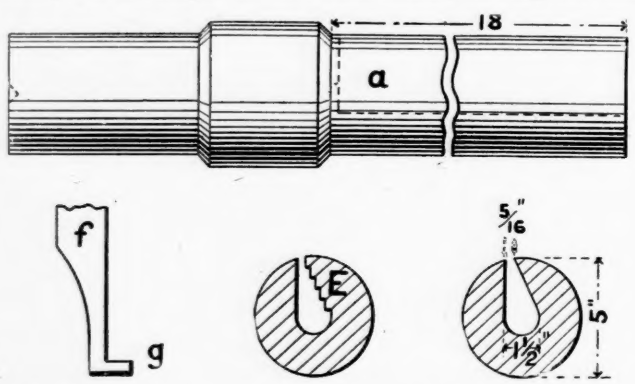
The engineer-in-chief is the man above all who should thoroughly understand the proper economical manner of operating his own particular plant, and the proper economical manner of handling the particular kind of fuel used. His duty it is to lay down the line of action for his firemen, and to see that they follow that line of action and no other. Instances are not wanting where an engineer has taken charge of a plant and with the same firemen and the same fuel as before, has shown a saving in fuel expense of from one-third to one-half.

The proper inspections of the boiler plant, involving as they do crawling about inside, behind and under boilers, is dirty, disagreeable work, and the engineer having firemen to perform all the dirty work of cleaning out, is tempted to leave these inspections to them entirely; but here is where he makes a mistake. These matters require the personal attention of the responsible chief, for no part of a steam plant is so subject to a rapid falling off in efficiency and economy from lack of the most unremitting care and attention, as these same boilers and furnaces. It can not be otherwise, from the very nature of the destructive and befouling processes going on therein. A. E. LOCKE.

Sacramento, Cal.

A PLANER JOB.

Your description of the open side planer in a late issue reminds me of an occasion I had to use the following shop kink, applied to work on a planer. Fig. *a* represents a tool steel roll in which there had to be a slot cut similar to end view shown Owing to the smallness of throat of slot and the depth, it was impossible to set planer-head over to cut the angle from the rough, so the method of stepping it out, as shown, was used to remove stock, but the trouble here encountered was the springing of the tool (an ordinary offset work tool), which made the tool actually cut in deeper on its return stroke, wearing the cut-



ting nose so that only one or two cuts could be taken. Here we were in one of those every-day shop snags, but the kink removed it. I loosened nut on planer cross-rail screw, which gave me about $\frac{1}{32}$ inch play through the holes in planer housing. I put a 3 by 4 inch stick for fulcrum of a lever, took shop cub and initiated him to planer movement, in cutting stock, pull down, reverse, let-up. You see in this I had a release motion similar in action to the modern slotting machines, which did the work beyond our expection. The sizes are as near it as I can remember. J. L. HUMMER.

Syracuse, N. Y.

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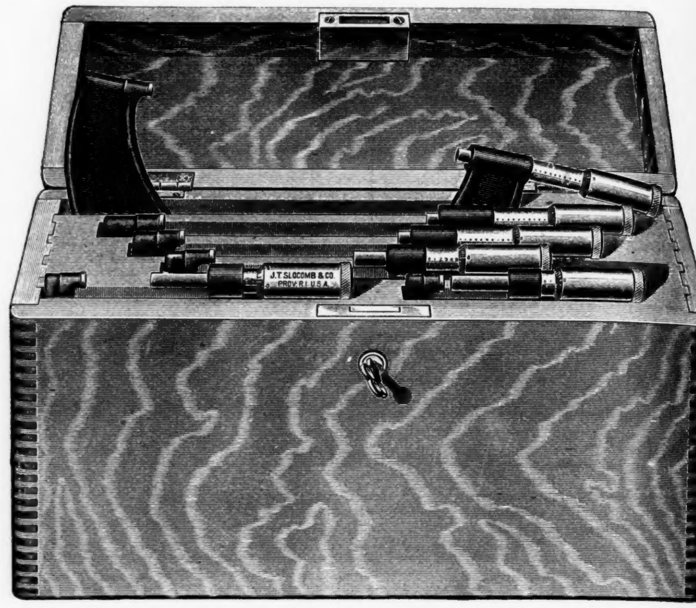
A 6-INCH MICROMETER SET.

The illustration represents a set of micrometer calipers measuring from 0 to 6 inches, or altogether what the average machinist would call a 6-inch micrometer.

Long use of the ordinary swing-leg or slide-bar calipers have given most machinists the impression that any caliper, to be good, requires a considerable range of movements; so when we come to consider micrometers as ordinary calipers, we need not be surprised to find a prevailing notion that a 6-inch micrometer caliper should measure all the way from 0 to 6 inches.



It will not require much of a delve among facts to show that such a 6-inch micrometer would be out of the question altogether for purposes of a portable caliper.

A caliper large enough to go over a 6-inch shaft, and as rigid as the case requires, would not, on account of its weight and bulk, be a suitable caliper to measure one inch work in the lathe.

A small screw or spindle that overhangs its points of support enough to cross a space of 6 inches would be too shaky for the required purpose. A micrometer screw to traverse 6 inches would be too expensive to make, and could not be kept sufficiently accurate; besides, it would require too much time to run it back and forth.

Upon the whole, it seems that the facts of the case point out plainly that the average conception of a 6-inch micrometer will not do.

The set shown in the illustration is designed to do the work of a practical 6-inch micrometer, without the objections that lurk in the path of the single tool theory. Of course, a 6 inch set is not intended for machinists' private use, but more in the line of shop gauges. A 3-inch set of three calipers makes a valuable machinists' outfit, and is not very expensive.

Of course, where so many separate tools are required to cover the range it is desirable to economize in cost and economy in construction has been given due attention in this 6-inch set. While there are no essential features omitted, there are no unnecessary ones included. The design right through is for a tool or set of tools intended to do *work* and to do it in the most convenient manner. The frame or bows are made with an I section, to secure the greatest rigidity with lightness and also to afford a good finger hold, and are finished by japanning. There is no opening that will admit dust or dirrt to the threads of micrometer screw. There is no screw used in the anvil, this part being solid. The adjustment for wear is situated inside the thimble and is a differential screw adjustment, which is very fine (amounting to a single screw of 160 P.), allowing of adjustment more easily than by a coarse screw. The graduated end of thimble can be easily used to denote the required amount to turn adjusting screw and is the means adopted in its manufacture. The micrometer screws are made of a good quality of tool steel, and the threads are cut on a special machine that does the work very nicely. There is a

compound linear scale used which may be read in decimals in the usual way or in eighths and decimals as may be desired.

These are made by J. T. Slocomb & Co., 227 Eddy St., Providence, R. I.

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We have received the following letter from Mr E. J. Skinner, of New Britain, Conn., and think it would be interesting to have all those who know of other or higher chimneys to inform us of their location:

"In your article, 'Tallest Chimneys on Earth,' by W. Barnet Le Van, we find this statement: 'The following table gives the height of *all* the chimneys in the world that are over one hundred and fifty feet in height.' This statement should have been modified somewhat, as there are at least two chimneys in this city which should properly be included in the list. We are not prepared to give any dimensions, but the chimney of the Russell & Erwin Mfg. Co., also the one of P. & F. Corbin, are both over over one hundred and fifty feet in height."

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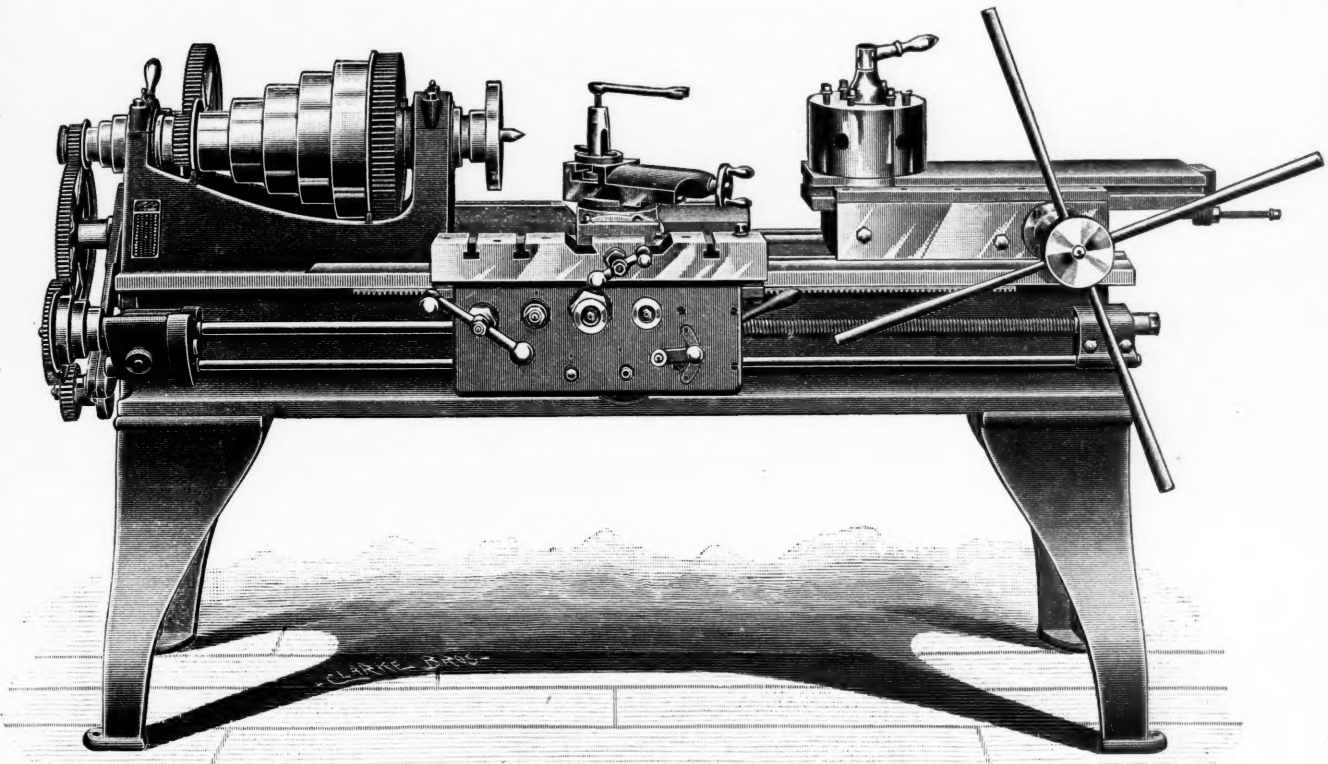
A NEW TURRET ENGINE LATHE.

The demand for rapid lathe work, together with the increasing knowledge regarding the value of the turret lathe, has led to the adoption of the turret and sliding carriage on the regular engine



lathe in place of the usual foot block or tail stock. This is the latest type of the 18-inch "Springfield Muller" engine with turret added, and is made by the Springfield Machine Tool Co., of Springfield, Ohio. The tool is carefully designed to meet the requirements for heavy service and, though very solid and rigid, the convenience of the operator has been carefully looked after. The principal dimensions are as follows, and will serve to show that the essential details have been carefully considered:

Diameter of front journal of spindle	2¾ in.
Length of front journal of spindle	4½ in.
Diameter of hole through spindle	1 5-16 in.
Diameter of largest step of cone	12 in.
Width of belt	2⅛ in.
Ratio of back gearing	12 to 1
Swing over bed	18¼ in.
Swing over carriage	12 in.
Weight	2,200 lbs.

The spindle is threaded but two-thirds of its length with a U. S. S. thread of 4 to the inch. This gives the face plate a straight bearing of one-third its length on the nose of spindle which aids in putting it in place and adds to wearing qualities.

The combination of a turret with the usual engine lathe offers advantages possessed by no other arrangement, if its use was contemplated in the original design and not an after consideration, so frequently the case. With this in view the wearing surfaces for taking the thrust on live spindle are of unusual proportions—more than equal to the requirements imposed on them when constantly used for chucking purposes.

Inasmuch as perfect alignment of turret is of vital importance, ample provision is made to accurately compensate for all wear tending to destroy same.

These turrets are made either to revolve automatically or by hand, and with or without power feed and stop attachment.

The parts necessary to automatically revolve turret are made of tool steel, with all surfaces subject to abrasion hardened. The turret is 9 inches in diameter, is bored to receive six tools and has a movement of 10 inches.

A desirable feature allows the use of an endless belt and so avoids all the annoyance due to lacing or hooks. This enables the desired tension to be given to the belt, so that in an extra heavy cut the belt can be tightened to prevent slipping and again slackened when the heavy duty is over.

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ANOTHER TORPEDO BOAT DESTROYER.

The launching of the *Sokol*, built for the Russian government at the yards of Messrs. Yarrow & Co., the well known shipbuilders, was an interesting event in many ways. It is 190 feet long by 18½ feet beam, and is the first boat of this class in which nickel steel has been used. Twin screws are driven by engines of 4,000 H. P., and steam is supplied by eight Yarrow water tube boilers with straight tubes. The guarantee was 29 knots on a three hours' trial, carrying 30 tons. There are two torpedo tubes on deck so as to fire over either side, one 12 pounder and three 6-pounder quick-firing guns.

A very sensible custom of these yards is to omit all launching ceremony, and in this case the boat was launched with all machinery on board, fires lighted and steam raised in four of the boilers. After the launching the main and auxiliary engines were at once tested under steam. At the trials next day a mean maximum speed of 30¼ knots was obtained, both with and against the tide, without exceeding the 4 000 H. P. calculated. The maximum steam pressure used was 165 pounds. This gives the Russian government the fastest vessel afloat.

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Mr. E. B. Wilson, Secretary of the National Association of Manufacturers, announces a postponement of the annual convention at Chicago, Ill., until November 19th, 1895.

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BUSINESS.

An inquiry for the address of a manufacturer of endless wire cables of small diameter has been received, and anyone in this line should address this office.

The parties desiring the hat-block machine want to find a regular maker of them, not to have one designed. The other inquiries have been satisfactorily answered.

MANUFACTURING NOTES.

THE AMERICAN TIN PLATE Co. of Elwood. Ind. are making extensive additions to their already large plant, and will be able to supply next year about five times their present output. They are adding quite a number of new machines to their repair shops, among which is a large upright drill made by the Lodge & Davis Machine Tool Co., of Cincinnati, O.

MESSRS. LODGE & DAVIS have taken a novel way to dispose of their World's Fair lathe, resplendent with nickel and gold plate, white enamel, plush lined tool shelves, etc., which cost about $1,500 to prepare for the exhibition. Everyone in the United States interested in the development of technical and mechanical education is requested to cast a vote for their favorite technical or mechanical school, and the one receiving the greatest number of votes before noon of March 1st, 1896, will be presented with the lathe. The full name and address of each voter must be given ; and no duplicate votes will be recorded. Graduates and others interested should endeavor to secure this for their favorite school, for it is a valuable tool aside from the luxurious trimmings.

MESSRS. RHEILE BROS., of Philadelphia, have sent a new large size testing machine to the Atlanta Exposition. This embraces all the latest ideas in machines of this class, having automatic and autographic registers and a capacity of 100.000 pounds. These machines are well-known for their accuracy and convenience, and this exhibit is sure to attract attention at the Exposition.

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FRESH FROM THE PRESS.

THE LIDGERWOOD MFG. Co., of New York City, have in the press a new pamphlet entitled "Traveling Cableways, and some Other Devices Employed by the Contractors on the Chicago Drainage Canal." This book will be one of their well known sketch book series, same size as the previous issue, and will contain 72 pages, 36 full-page illustrations, and is intended particularly to illustrate the multiplicity of uses to which the Lidgerwood hoisting engines can be placed. The traveling cableways, twenty of which have been sold and used on the Chicago Drainage Canal, occupies the larger part of the book. It will be for free distribution, and those desiring a copy should apply to the Lidgerwood Mfg. Co., of 96 Liberty street, N Y.

THE HEINE SAFETY BOILER Co., of St. Louis, Mo., send us a copy of their second edition of HELIOS, a valuable book of 178 pages, and while it can be classed as a catalog, it is a welcome addition to our library. It shows the merits of the boiler in a very interesting manner, and these are vouched for by numerous severe tes s, one of which earned a bonus of $1,500 by showing a better evaporation than 8 pounds of water per pound of coal, as guaranteed. The information contained in this book is of the highest character, the tables, formulas, data and other matter being thoroughly reliable and reflecting great credit on the author, Mr. E. D. Meir, the president and consulting engineer of the company. It compares very favorably with many publications selling for a good price, and has the advantage over some of them of being thoroughly up to date. We do not know how freely they are distributed, but every engineering association will be gladly supplied, and engineers holding responsible positions can probably obtain a copy on application. The possessor of this volume can consider himself fortunate, and should add much to his store of knowledge.

THE entire main line of the New York Central, from New York to Buffalo and Niagara Falls, is protected by the most perfect system of block signals in the world.

MR. A. D. QUINT, Hartford, Conn., has recently issued a catalog of his Turret Drills, which are well known as labor savers in some of the best shops. The work remains on the table while different drills and taps are brought into position as desired; only the one in use revolving. These tools are made in several sizes and designs, and those who have much drilling or tapping will do well to become acqu.inted with these machines.

THE Empire State Express, New York Central's fastest train in the world, is a striking example of railway progress in the nineteenth century, and is only one of twelve great through trains that leave Grand Central Station, each day—practically a train every hour.

THE WHITING FOUNDRY EQUIPMENT Co , 1532 Monadnock Block, Chicago, Ill., send us a 32 page, standard size catalog showing the different types of cranes made by them. It abounds with half-tones and affords the student of design with many good object lessons in crane design, as well as the foundryman with a large variety from which to select those best suited to his needs. They comprise traveling cranes, jib cranes of various styles and sizes, and nearly all are adapted for the use of electric, steam or compressed air. Air hoists and compressors are shown, and hand hoisting cranes are also in the list. There is much to interest the mechanic and the foundryman in this catalog, and it will be a valuable addition to any collection.

ARMSTRONG BROS. TOOL Co., 87 Edgewood avenue, Chicago, Ill., favor us with handy little catalog of their tool holders, which are becoming more popular every day. Those who are not familiar with them should not delay in sending for this catalog, as it will convince them that they have use for them in their own shop for a large variety of work. With over 30,000 in use and an increasing demand, there is little need be said regarding the merits of the tools. A postal card will bring the catalog and show how money can be saved.

WE are in recept of the STATIONARY ENGINEERS GAZETTEER, of Illinois, which is a neatly bound book of nearly 140 pages, 9 by 12 inches. It contains a complete list of chief engineers of all steam plants in Illinois, names of officers, location and night of meeting of a stationary engineers' association in that State, list of supply houses and other information of interest to engineers and those who have dealings with them. This will be found a valuable reference book, and as the publishers offer to furnish engineers and firemen as well as to aid those seeking employment, it is to the interest of every engineer to become familiar with their methods. It will be sent free to any engineer in the State of Illinois on application to the Stationary Engineers' Gazetteer Association, 159 La Salle street, Chicago, or will be sent to anyone outside of the State for $5.00.

JULIUS HANSEN, 40 Hawley street, Buffalo, N. Y., favors us with his price list for 1895-96, showing his improved machinists' tools as well as several of the Columbia calipers which he handles. He also makes standard gauges, test bars, limit gauges, etc. A postal card brings the price list to any mechanic.

PRACTICALLY every hour the New York Central has a through passenger train to the North and West.

THE GISHOLT MACHINE Co., Madison, Wisconsin, send us a late catalog of their well-known tools, and as they give practically their entire attention to the development of heavy turret machinery, the result is a line of tools which will interest any wide awake foreman or superintendent. Good illustrations and plenty of them tell the story better than lengthy descriptions, and the methods of doing certain work, together with the time taken, is a good object lesson to the shop manager who hesitates to purchase new machinery. Their tool grinder is also shown and is a fit companion for their other labor saving tools.

THE PHILADELPHIA ENGINEERING WORKS, LTD, Philadelphia, Pa., have favored us with their latest catalogs on air pumps, condensers, heaters, fly wheels, steel chimneys, simple and compound engines and rules and tables for the equalization of power developed in the cylinders of compound engines. These are all standard size and form a valuable practical treatise on steam engineering of to-day, as this company is thoroughly modern in its methods and its products. These catalogs will be highly valued by those fortunate enough to possess them and will be used as a reference in many cases where an authority is desired on the subject named.

MR. W. H. BALDWIN, JR., Third Vice-President of the Southern Railway, has issued a circular directing that employees of the Southern Railway who have been in its service for a period of one year or more, shall be given leaves of absence and passes to Atlanta and return for themselves, their wives and dependent children. This is a good example, and will propably be followed by other railroads.